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*Illustrated. **Letter to the Editor. †Editorial. ‡Author of Book Review. §Obituary.

The Canadian Engineer

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UNIVERSITY BRIDGE, SASKATOON

TEN-SPAN CONCRETE BRIDGE IS 1,407 FEET BETWEEN EXTREME ENDS OF APPROACH WALLS, AND IS BUILT TO GRADE OF 2.88 PER CENT.—SUMMARY OF COSTS, SPECIFICATIONS AND CONSTRUCTION METHODS.

144609
6/12/17

By C. J. YORATH, A.M.Can.Soc.C.E., A.M.I.C.E.,
City Commissioner, Saskatoon, Sask.

IN the early part of 1913 an agreement was entered into between the city of Saskatoon and the provincial government of Saskatchewan, whereby it was agreed that the latter would construct a reinforced concrete bridge over the Saskatchewan River, running south-easterly from 25th Street and Spadina Crescent to the corner of College Street and Clarence Avenue. This site was chosen principally with the idea of providing more direct communication between the University of Saskatchewan, which is located on the east bank of the river, and the central business portion of the city on the west bank. The only other means of access across the river is by means of a steel truss bridge, which, on account of its width (25 ft. 6 ins.) often becomes congested with traffic.

Photo February 1st 1916

View of Bridge from East Bank of River, Showing Cantilever Sidewalk.

The agreement between the city and the government provided for a bridge 62 feet wide, with two sidewalks 8 ft. 6 ins. wide, and a carriageway 45 ft. wide, to be designed to carry a double line of street railway tracks, and provided with a conduit to accommodate sewer, water and electric mains. It was originally intended to carry the piers of the bridge upon reinforced concrete piles, but it was found upon trial-holes being made, that immediately below a strata of gravel and boulders averaging in depth about five feet, and which formed the bed of the river, there was a strata of unknown depth of hard, blue clay which would make an excellent foundation for the load to be carried by each of the piers.

A contract was let to the R. J. Lecky Company in June of 1913 which amounted to $240,004.86 at the unit prices quoted in the tender, the provincial government undertaking to supply the cement and all steel work, which was estimated to cost $158,000, so that the total estimated cost was $398,004.86. The highest tender received, including the cost of material to be supplied by the government, amounted to $755,594.

Unit Prices.—The unit prices quoted in the accepted tender were as follows:—

For concrete in piers and abutments below the springing line of arches and in retaining walls, placed, waterproofed and finished as specified, per cubic yard, $4.77.

For all concrete above the springing line of arches (except concrete in fence and posts or concrete used in pavement or otherwise paid for) furnished waterproof and placed as specified, per cubic yard, $5.87.

View from University Campus, October, 1916. *Photo by Finley, Saskatoon*

For concrete fence above line of sidewalk, as shown on plan, per lineal foot, $1.

For rip-rap, if required, price per cubic yard in place, $18.

For wooden piling under foundations and required in finished structure, price per driven foot, $.40.

For concrete piling under foundations and required in finished structure, price per driven foot, $1.05.

For dry excavations measured as specified to get proper foundations, per cubic yard, $.90.

For wet excavations, including cofferdams measured as specified to get proper foundations, per cubic yard, $7.07.

For sidewalk on approaches and over earth-filled parts of bridge, per square foot, $.15.

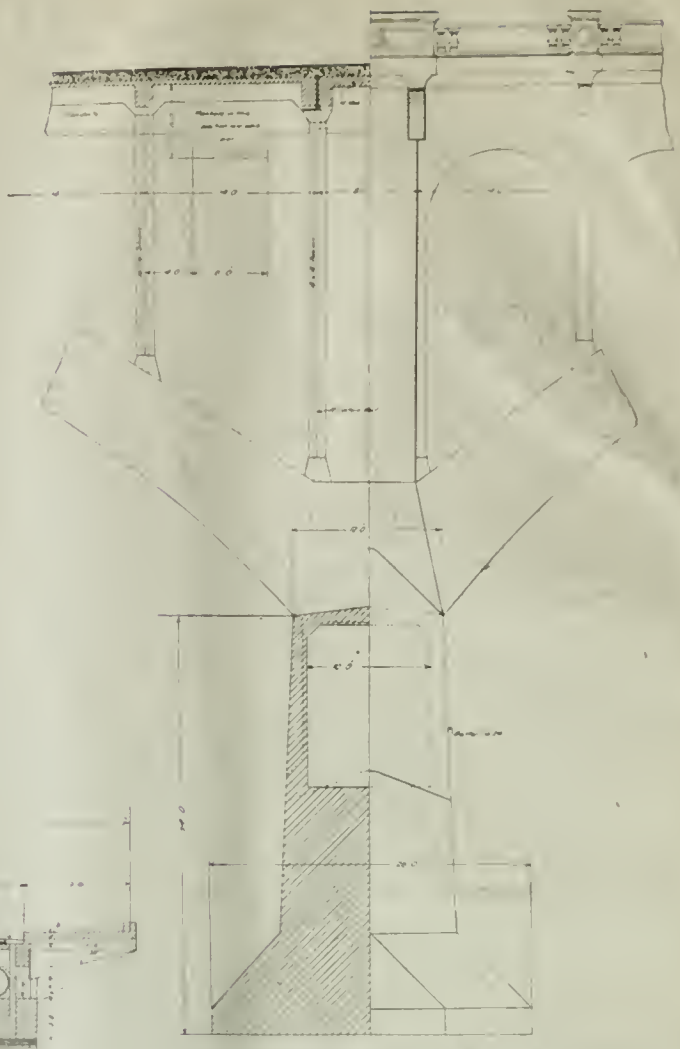
For curb and gutter in approaches and over earth-filled parts of bridge, $.35.

For embankment in approaches, $.35.

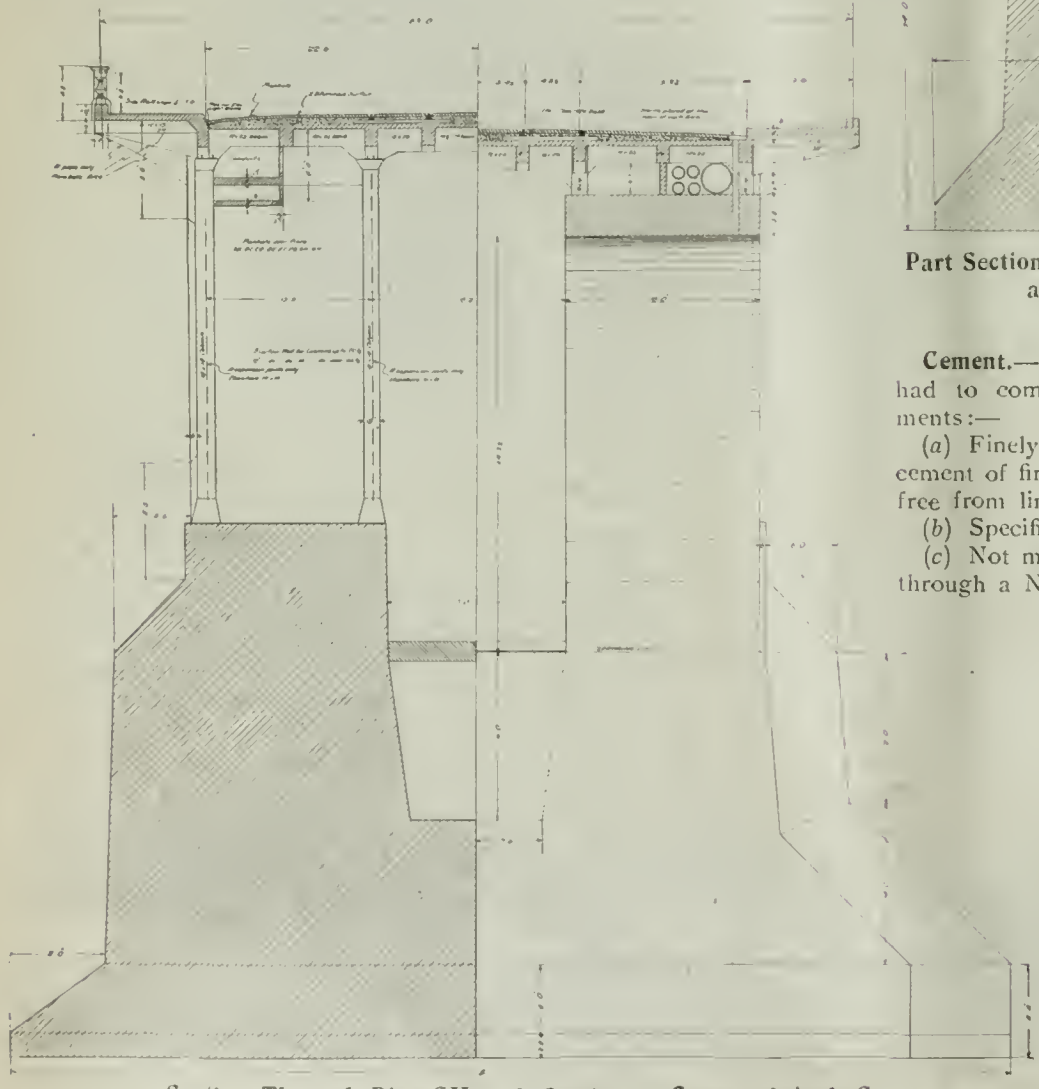
For the supply of all material not otherwise provided for; falsework and centering; conduits, manholes, manhole covers, ladders and drainage system complete; and for all labor and material required to carry out the work not otherwise paid for,—the lump sum of $79,141.

The specification provided for the following:—

Steel.—To be soft or medium having an ultimate strength of 55,000 to 75,000 pounds per square inch, to bend cold 180 degrees on its own diameter without cracking.



Part Section Through Centre of Pier GH and Part Elevation.



Section Through Pier GH and Section at Crown of Arch G.

Cement.—All cement used in the works had to comply with the following requirements:—

(*a*) Finely ground, fresh-burned Portland cement of first quality and approved brand, free from lime and other impurities.

(*b*) Specific gravity not less than 3.10.

(*c*) Not more than 1% to be left unsifted through a No. 50 sieve; not more than 8% on a No. 100 sieve; and not more than 25% on a No. 200 sieve.

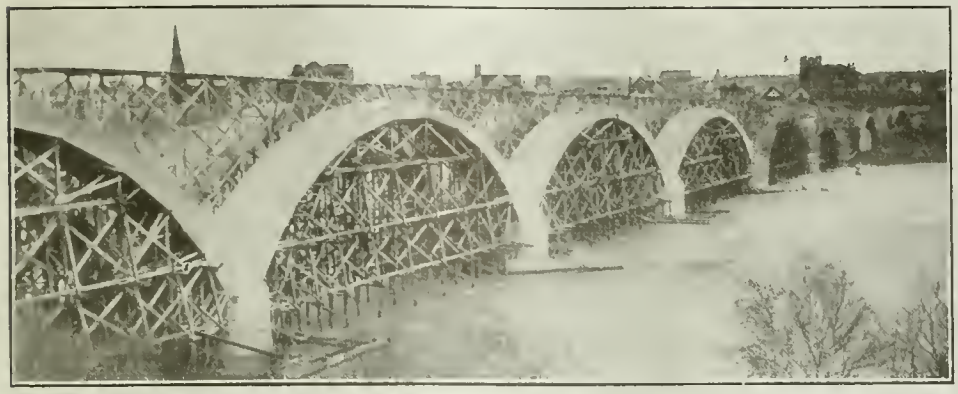
(*d*) Tensile strength to be not less than 150 lbs. per square inch and not more than 450 pounds after a period of 24 hours. Briquettes made of one of cement to three of sand to develop the following strength:—

1. After 24 hours in air and 6 days in water, not less than 150 lbs. per square inch.

2. After 24 hours in air and 27 days in water, not less than 200 lbs. to the square inch.

Neat cement to develop its initial set in not less than 30 minutes and its final set in not less than three hours.

Loading for Floors.—(*a*) On each car track a concentrated load of 100 tons carried on two trucks having a wheel spacing of 5.15.5 feet between centres of wheels along rails, each wheel carrying 12.5 tons.



Showing Timber Centering for Arches Carried Upon Piles, Trestle Carrying Concrete Delivery Pipe, and Reinforcing for Spandrel Columns.

(*b*) On remaining part of floor surface a concentrated load of a 25-ton traction engine, wheels 8-foot centres and 10 feet between axles, two-thirds of weight on rear wheels which are 30 inches wide.

(*c*) On sidewalks a uniform load of 150 lbs. per square foot.

Loading for Arch Rings.—(*a*) A uniform load of 200 pounds per square foot for the centre 17 feet of the bridge.

(*b*) A uniform load of 150 pounds per square foot for the remaining floor surface of the bridge.

(*c*) A uniform load of 150 pounds per square foot for sidewalks.

Working Stresses.—The allowable stresses in the materials not to exceed the following:—

Compression in concrete, 600 pounds per square inch.

Tension in concrete, not reinforced, 0 pounds per square inch.

Shear in concrete, 50 pounds per square inch.

Tension in steel, 13,000 pounds per square inch.

Compression on steel, not more than 15 times that of concrete.

Foundation Pressures.—Four tons to the square foot.

Temperature Variation.—A range of temperature from — 50 degrees to + 90 degrees Fahrenheit was assumed for the calculations of temperature stresses.

Quantities and Dimensions.—The total length of the bridge between the extreme ends of wing approach walls is 1,407 feet and is built to a grade of 2.88 per cent., the east end of the bridge being 35 feet higher than the west end.

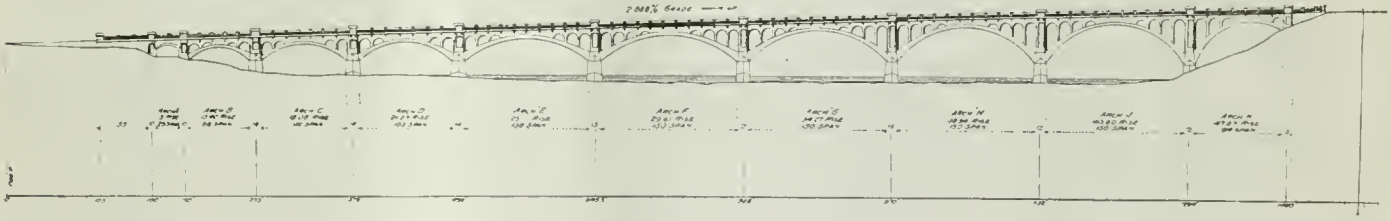
There are ten arches, with the following spans:—

Clear span.	Centre to centre of piers.
25 ft. 0 in.	34 ft. 0 in.
66 ft. 0 in.	78 ft. 5 ins.
92 ft. 0 in.	106 ft. 0 in.
103 ft. 0 in.	117 ft. 0 in.
136 ft. 0 in.	149 ft. 0 in.
150 ft. 0 in.	162 ft. 0 in.
150 ft. 0 in.	162 ft. 0 in.
150 ft. 0 in.	162 ft. 0 in.
150 ft. 0 in.	162 ft. 0 in.
94 ft. 0 in.	106 ft. 0 in.
Total span	1,238 ft. 5 ins.

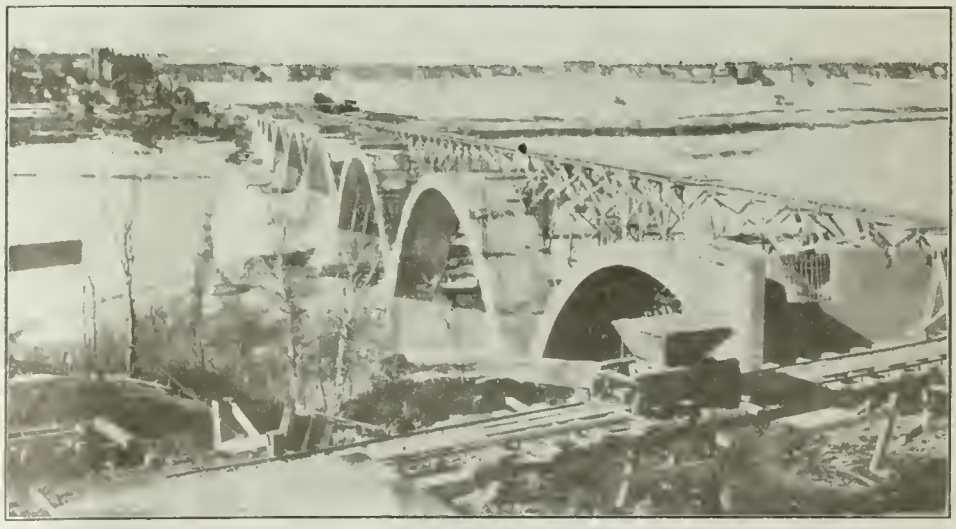
The bridge contains 23,000 cubic yards of concrete and 1,015 tons of steel.

The larger spans contain in the arches sixty-four 1¼-inch diameter rods having an area of 78.54 square inches, one-half being extrados and the other half intrados rods.

The area of steel in the beams varied from 8⅝-inch diameter rods having an area of 2.45 square inches in 12-in. x 23-inch beams to 10⅞-inch diameter rods having an area of 6.01 square inches in 16-in. x 29-in. beams.



Elevation, University Bridge, Saskatoon.



East Abutment. Centering Removed. Before Pouring Spandrel Columns or Floor System.

The area of steel in the floor slab averaged .47 square inches of steel per lineal foot; also temperature rods ½-inch diameter, spaced 10 inches centre to centre.

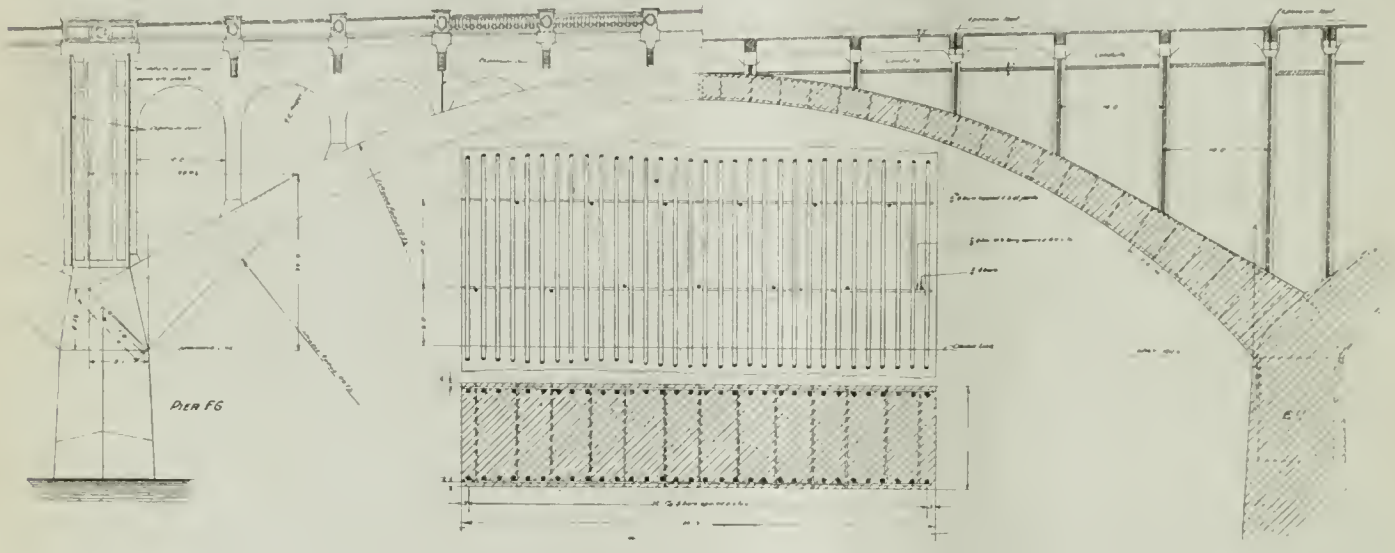
The extreme dimensions of foundation for largest piers was 84 ft. x 26 ins. and the average dimensions of main body of pier (without ice breaks) 48 ft. x 13 ft., and the height from base to springing line of arches, 34 feet.

Construction Methods.—The concrete for piers was poured when the river was frozen over. Inside cofferdams were constructed with Wakefield sheet piling made on the job and consisting of three layers of 2-inch planks spiked together so as to make tongues and grooves. Generally, two rows were driven about two feet apart and were puddled between with clay.

The concrete in arches was poured from a pneumatic mixer fixed on the east bank of the bridge. The 94-foot arch was poured first, and then a discharge pipe from the mixer was conveyed upon a timber trestle and extended as each arch was required to be poured.

layers of tarred felt. The beams, which run transversely to the bridge, are double at expansion joints. One beam was poured monolithic with the columns supporting it, and the other beam is separated from the column by a bronze plate set in that half of the column under this beam. The two beams are separated by several thicknesses of tarred felt. The cantilever arm opposite this joint is made monolithic with one of these beams, and separated from the other by a paper-filled joint. The fence and outside longitudinal stringers also have an expansion joint at the end of the cantilever arm, the lower bronze plate fixed to the top of the cantilever arm, and the other plate attached to the under side of one of the outside stringers at the same point.

The ends of stringers have an expansion joint somewhat similar to a tongue and groove, with layers of tarred felt between. Over the beams and cantilevers the expansion joint is carried up through the floor slab and sidewalk with several layers of tarred felt. Through the paving base the expansion joint is formed by a joint filled with sand and bitumen.



Plan and Section at Crown and Part Elevation, Arch G.

The mixer used was a vertical cylinder with cone-shaped ends, having an air-tight door on top, worked by air valves through which ingredients were introduced. At the bottom of the cylinder there were several 2-inch air pipes controlled by a valve. The air for the mixer was supplied by two air compressors at a pressure of 90 pounds per square inch at the commencement of forcing the concrete from the container through the delivering tube.

The operator of the mixer stood beneath the loading platform, and after allowing the charge to be emptied into the container, along with sufficient water, closed the top door and then turned in air at the 90 lbs. pressure. After a few seconds he opened the tower door and allowed the charge of concrete to be blown through the delivering pipe to the receiving hopper. The concrete for spandrel columns was poured from wheelbarrows loaded from the receiving hopper fed by the pneumatic mixer.

Owing to the great variation in temperature in Saskatoon, ample provision had to be made for expansion joints. The upper portion of the superstructure, including the floor system, is divided transversely by expansion joints at each side of the pier and at two other places in each span. At these points the spandrel walls are divided by a vertical joint, V-shaped, which is filled with several

The total cost of the bridge was approximately $520,000, two-thirds of which was borne by the provincial government and the remaining third by the city. The structure was designed in the Highways Department of the Provincial Board of Highway Commissioners.

HARBOR AND CANAL EXTENSION IN SWEDEN.

The construction of the new Trollhätta Canal has led to a series of other work in connection with harbors and waterways. It is now being urged that the canal between Lake Vänern and Lake Vättern should be improved so as to have the same depth and breadth as the new Vänern-Gothenburg waterway. At Kristinehamn extensive harbor works have been going on for several years, entailing an expenditure of some 4,000,000 kroner. The work is now completed and the new harbor is about to be opened. The depth is 4 m. (13 ft.), and quays, store accommodation and ample railway connections have been provided.

Since the fire of 1906 the city of San Francisco has issued a total of 66,278 permits for building construction, the value of which was $292,846,885. The figures include eighty-three exposition buildings.

CANADIAN ELECTRIC POWER EXPORTERS.

The growing and somewhat insistent demand for power on the part of the municipalities of Ontario for industrial and domestic purposes has brought the question of a reduction of the export quantities granted by license to the hydro-electric companies at Niagara Falls before the department of inland revenue for revision, states Mr. J. V. Vincent, in his annual return. The electricity exportation act provides that licenses to export "shall be revocable upon such notice to the licensee as the governor-in-council deems reasonable in each case." Under the circumstances a yearly reduction in the quantities to be exported might be deemed a reasonable method of putting an end to the export.

Name of contractor and place of business.	Units produced for export.		Units produced for use in Canada.		Total output of generating station or other source.	
	K.W. Hours.	H.P. Years.	K.W. Hours.	H.P. Years.	K.W. Hours.	H.P. Years.
Canadian Niagara Power Co. .	400,521,090	61,289.01	11,178,910	1,710.59	411,700,000	62,999.60
Electrical Development Co. ...	34,652,000	5,302.56	395,346,500	60,497.02	429,998,500	65,799.58
Ontario Power Co.	199,135,160	30,472.28	616,834,440	94,389.93	815,969,600	124,862.21
*International Railway Co. ...	.....	.....	.....	.....	.....	.....
Ontario & Minnesota Power Co.	13,144,070	2,011.33	11,789,534	1,804.08	24,933,604	3,815.41
Cedars Rapids Power Co.	358,753,000	54,897.51	56,031,000	8,574.03	414,784,000	63,471.54
Sherbrooke Railway and Power Co.	230,820	35.33	8,605,200	1,316.79	8,836,020	1,352.12
Maine and New Brunswick Power Co.	3,075,893	470.69	242,437	37.09	3,318,330	507.78
Western Canada Power Co. ...	11,937,700	1,826.73	60,468,020	9,253.00	72,405,720	11,079.73
British Columbia Electric Railway Co.	330,626	50.59	68,470,689	10,477.60	68,801,315	10,528.19
Totals	1,021,780,359	156,356.03	1,228,966,730	188,060.13	2,250,747,089	344,416.16

*This company's load is used for electric railway supply, chiefly on Canadian side of boundary.

Electrical standardizing laboratories have been established at Ottawa and Vancouver, where the substandards used by the department's inspectors are adjusted and standardized periodically, also such electrical instruments as may be presented by the general public. The equipment for another similar laboratory at Winnipeg has been provided and awaits suitable accommodation for the installation thereof.

The revenue collected from weights and measures inspection was $112,136; gas and meter inspection, $46,034; electric meter inspection, $70,051; making a total from this source of $228,221.

The amount of electrical energy produced for export and consumption in Canada for the year ended March 31st, 1916, is as follows:—

CEYLON RAILWAYS.

The length of railway open for traffic in Ceylon at the close of September, 1915, was 692½ miles, as against 672 miles at the corresponding year of 1914. The increase was due to the opening of a section of a line to Chilaw. In the course of 1914-15 rolling stock was increased by 18 new passenger and 186 new goods vehicles, including a number of tank wagons. The total expenditure to the close of September, 1915, including additional accommodation and improvements, amounted to £7,858,452. The Chilaw line was approaching completion in 1915, and it has been opened to Kochchikade for all descriptions of traffic. Steady progress was made with the Pelmadulla and Badulla extensions, especially on sections between Ratnapura and Dela and between Bandarawela and Ella. Work is in progress on Colombo station extension, and a large broad-gauge goods shed and connecting sidings have been brought into use. Earthwork is in hand on a main line duplication between Ragama and Veyangoda. A survey from Chilaw to Puttalam has been commenced, and a survey connecting the harbor line with the railway, via Mutwal, has been completed.

WORK OF U.S. OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING IN 1915.

Over 4,942,000 sq. yds. of roadway, the equivalent of 561.9 miles of road 15 ft. wide, were constructed under the supervision of federal road engineers during the last fiscal year, according to the annual report of the Office of Public Roads and Rural Engineering, of the United States Department of Agriculture, just issued. This is more than double the mileage so constructed in previous years.

The yardage of the different types of surfacings constructed last year were as follows in square yards: Gravel, 1,848,280; macadam, 1,565,163; earth, 767,437; bituminous macadam, 310,643; sand-clay, 295,337; concrete, 84,454; bituminous concrete, 39,813; surface treatment, 30,835.

The roads constructed under supervision of the office include experimental roads, post roads, county roads, and roads in National Parks and forests. The expenditures of the office for this purpose were chiefly for engineering services and supervision, the communities, except in the case of forest and park roads, meeting the bulk of the costs for material and construction.

Ferro-vanadium exports from the United States have reached a total of 1,062,932 lbs. for the first eight months of this year and are constantly expanding. While the exports reached over 1,000,000 lbs. for the 12 months ended June 30th, 1916, they will amount to 1,594,396 lbs. for 1916, if maintained at the present rate.

The British Consul-General at Havre reports that the iron mines and blast furnaces of Caen (Normandy) are at present being worked by the Government, and that the industry, which was languishing for many years past, is now most flourishing. A large new plant of the most modern type is being installed, and the railway authorities are doing their utmost to assist the development of the industry. The output of iron ore in this district has now reached over 1,000,000 metric tons per annum.

Tungsten deposits in California, which remained practically unknown until the spring of 1916, have recently yielded considerable quantities of the mineral under the stimulus of the increased demand. The ore consists of scheelite associated mainly with garnet, epidote and quartz, and averages about 2 per cent. of tungsten trioxide

It appears that as a result of war conditions in Germany, carbon electrodes for furnaces are now being standardized. According to the new rules, round carbons for steel furnaces are to be made in sizes varying in thickness from 100 mm. upwards by steps of 25 mm., the tolerance varying from 3 mm. to 6 mm., according to size. For rectangular electrodes used with other kinds of furnaces, a standard size of 500 mm. square is being proposed. For the time being, the standard length is fixed at 2 m.

RECOMMENDED SPECIFICATIONS FOR REINFORCED CONCRETE DESIGN.

THE Portland Cement Association has issued recently specifications for reinforced concrete design. The specifications are based on the regulations in the building code recommended by the National Board of Fire Underwriters and the 1916 report of the Joint Committee on concrete and reinforced concrete. The specifications follow:—

Loads.—The schedule of superimposed uniform (live) loads per square foot is as follows:—

Roof ..... pounds per square foot
..... floor ..... pounds per square foot
..... floor ..... pounds per square foot
Etc.

The roof slab, together with the roof beams and girders, shall be designed to carry the full live and dead loads. All floor slabs and beams shall be designed to carry the full live and dead loads. All girders under floors where the assumed live load is under 120 lbs. per square foot shall be designed to carry all the dead load and 85 per cent. of the assumed live load. No deduction for floor loads greater than 120 lbs. per square foot.

Every column, post or other vertical support shall be of sufficient strength to bear safely the combined live and dead loads transmitted to it.

The following reductions are permissible when the live loads are under 120 lbs. per square foot:—

For columns supporting roof: No reduction.

For columns supporting top floor: A reduction of 10 per cent. of the live load of the top floor may be made.

For columns supporting each succeeding floor: A reduction of 5 per cent. of the live load per floor may be made, but the maximum deduction for any floor shall not exceed 50 per cent. The reductions shall cease when a floor carrying a live load of more than 120 lbs. per square foot is reached.

For floors, beams, girders and vertical supports carrying machinery: At least 25 per cent. shall be added to the stresses from live loads to provide for effect of impact and vibration.

For sidewalks between the curb and building lines: Live loads shall be taken at 300 lbs. per square foot or a concentrated load of 5 tons at any point.

Materials.—Cement: The cement shall meet the requirements of the current Standard Specifications for Portland Cement of the American Society for Testing Materials.

Steel: The steel shall meet the requirements of the current Standard Specifications for Reinforcing Steel of the American Society for Testing Materials.

Aggregates and Water: The aggregates and water shall meet the requirements of the current specifications for aggregates and water of the Portland Cement Association.

Broken stone or pebble concrete not reinforced shall be assumed as weighing 144 lbs. per square foot, and when reinforced shall be assumed as weighing 150 lbs. per cubic foot.

Stresses.—Extreme fibre stress in compression for 1:2:4 concrete, 650 lbs. per square inch. For 1:1½:3 concrete, 810 lbs. per square inch.

In direct compression, 1:2:4 concrete, 450 lbs. per square inch. 1:1½:3 concrete, 560 lbs. per square inch.

Shearing stress in concrete when diagonal tension is not resisted by steel, 40 lbs. per square inch for 1:2:4 concrete and 50 lbs. for 1:1½:3 concrete.

Unit shearing stress when web reinforcement is used, 120 lbs. per square inch, of which 40 lbs. per square inch may be resisted by the concrete.

In proportioning the section of concrete for shearing stress, the effective depth from centre of compression area to centre of steel area shall be used. In beams of T-section the width of the stem shall be used. In ribbed floors the width of the stem and thickness of flange near supports shall be proportioned for cumulative shear on the span.

Bond stress between concrete and reinforcement, 80 lbs. per square inch for plain and deformed bars, based on actual section.

Tensile stress in steel, 16,000 lbs. per square inch, for main reinforcement. Tensile stress in stirrup steel, 10,000 lbs. per square inch.

Ratio of deformation of steel to 1:2:4 concrete shall be taken as 1:15 and to 1:1½:3 concrete shall be taken as 1:12.

Compressive stress in steel shall be equal to the compressive stress in the concrete multiplied by the ratio of deformation.

In continuous beams and slabs the extreme fibre stress in concrete in compression may be increased 15 per cent. adjacent to supports.

Bearing on a concrete surface having a total area of at least twice the area of the loaded portion may be taken at 700 lbs. per square inch for 1:2:4 concrete and 875 lbs. per square inch for 1:1½:3 concrete, and, generally, at 35 per cent. of the ultimate strength of the concrete used, when all other stresses are properly provided for.

Slabs, Beams and Girders.—The straight-line method shall be used in designing reinforced concrete.

The span length for beams simply supported, and for all slabs, shall be taken as the distance from centre to centre of supports, but need not be taken to exceed the clear span plus the over-all depth of beam or slab. For continuous or restrained beams built monolithically into supports, the span length may be taken as the clear distance between faces of supports. Brackets shall not be considered as reducing the clear span in the sense here intended, and the clear span between T-beams is the distance face to face of stems. Maximum negative moments are to be considered as existing at the end of the span as here defined.

The bending moments of girders, beams and slabs due to uniformly distributed loads shall be taken as not less than:—

1/8 WL, at centre when simply supported.
1/9 WL, over central support; and 1/10 WL, near the middle of the span when continuous for two spans only.
1/10 WL, over first continuous support; and 1/10 WL, near middle of end spans when supported at one end and continuous at the other end for more than two spans.
1/12 WL, at centre and intermediate supports when continuous over more than two supports.

The simply supported ends of spans shall be reinforced for a negative moment of not less than 1/16 WL.

W = total distributed dead and live loads.
L = length of span.

Floor slabs having supports extending along the four sides shall be designed and reinforced as continuous over the supports. For uniformly distributed dead and live loads the per cent. of load carried on the transverse span shall be found by subtracting 0.5 from the quotient obtained by dividing the length by the breadth. The re-

mainder of the load shall be carried on the longitudinal span. If the length of the slab exceeds 1.5 times its width the entire load shall be carried on the transverse span. Using the values thus obtained, each set of reinforcement is to be calculated in the same manner as slabs having supports on two supports only, using correct depths to centre of steel. The amount of reinforcement thus determined per foot of width applies only to the middle half of the slab and one-half of this amount per foot of width may be used in each end quarter of the slab. The probable distribution of the loads from two-way reinforced slabs to supporting beams or girders shall be ascertained, and the moments in the beams or girders calculated accordingly.

The bending moments for slabs or beams with spans of unusual length or due to other than uniformly distributed loads shall be more exactly computed according to accepted theory.

In continuous slabs, beams or girders, full provision shall be made for the negative bending moments over the supports by placing sufficient negative reinforcement near the top of the members to resist the stress. This reinforcement shall pass beyond the point of contra-flexure in beams or girders and be anchored in the compression concrete of the member a sufficient distance to develop the full strength of the steel through bond stress. The critical section of continuous construction is over the support.

Where adequate bond is provided at junction between slab and beam, and the two are cast at the same time as a unit, the slab may be considered as an integral part of the beam, provided its effective width shall not exceed one-fourth of the span length of the beam, nor be greater than six times the thickness of the slab on either side of the stem.

In beams with T-sections the width of the stem only shall be used in calculating longitudinal shear and diagonal tension. An effective bond shall be provided at the junction of the beam and slab when the principal slab reinforcement is parallel to the beam, by the use of transverse reinforcement extending over the beam and well into the slab.

In the design of T-beams acting as continuous beams, sufficient compression area shall be provided on the under side at the support, either by the use of properly designed brackets or by embedding additional compression steel in the concrete extending to the point of inflection.

The minimum thickness of concrete floor slabs shall be 4 ins., and of roof slabs 3½ ins.

Cement or concrete floor finish shall not be considered in calculating the strength of floor members unless it be laid at the same time they are cast.

The design of composite floors consisting of rows of concrete tile or hard-burned terra cotta tile, gypsum blocks, sheet steel, or other approved fire-resisting material, separated by ribs, or beams of reinforced stone concrete, shall conform to all the provisions of these specifications so far as they are applicable. Not less than 2 bars shall be used in each rib with a minimum space between bars of 1 in. The width of ribs shall be 2 ins. plus the widths of the bars plus the spaces between the bars but the minimum width of rib shall be 4 ins.

The tile or blocks shall be regarded only as fillers, and shall not be considered in the design except as a dead load.

If designed as a T-beam, the slab portion above the fillers shall have a thickness of at least one-fifth the depth from the top surface to the centre of the steel and not less than 1½ ins., and shall consist of the same mixture used for the ribs, and shall be cast at the same time. Under these conditions it may be considered in the design of the ribs.

Tile or block fillers shall be laid with Portland cement mortar joints, and shall be thoroughly wet before the concrete is poured.

The protection for steel bars in the bottom of ribs shall be the same as for other beams.

To resist expansion and shrinkage stresses, reinforcement bars not less than ½ in. diameter shall be placed in the concrete at right angles to the ribs and above the fillers, at intervals not exceeding 30 inches.

Steel reinforcement shall have a minimum protection of concrete on all sides as follows:—

In columns and girders. 2 ins.; in beams and walls, 1½ ins.; and in floor slabs, 1 in.

The steel in footings for walls and columns shall have a minimum protection of 4 ins. of concrete.

All reinforcement shall be accurately located and mechanically secured against displacement during the placing of the concrete. Reinforcement bars for slabs shall not be spaced farther apart than two and one-half times the thickness of the slab. The spacing of parallel bars in beams shall be not less than two diameters from centre to centre, nor less than 1 inch. The clear spacing between two parallel layers of bars shall be not less than 1 in. In restrained or cantilever construction reinforcement shall extend beyond the supports into adjacent construction for full and effective anchorage, except that when this is not practicable, anchorage shall be obtained by other means acceptable to the (engineer or architect).

Special reinforcement shall be provided to resist concentrated loads.

Slabs reinforced in one direction only shall have shrinkage rods not less than ¼ in. in diameter placed above, and crossing the reinforcement and spaced not over 2 ft. apart.

All reinforcement shall be assembled well in advance of the placing of the concrete, and shall be inspected and approved by the (engineer or architect) before concrete is deposited.

Splices in reinforcing bars shall be designed to transfer the calculated stress at the joint either by bond and shear through the concrete or in vertical supports by bearing between the steel. Splices at points of maximum stress shall be avoided where possible. Lap splices of bars shall be of sufficient length to develop the required stress in the joint without exceeding the bond stress permitted, and the lapped portions shall be separated by a space not less than their thickness or a minimum of 1 in.

Members of web reinforcement in beams shall be designed for diagonal tensile stresses, using the calculated vertical shearing stress as a measure of these tensile stresses. The longitudinal spacing of vertical stirrups shall not exceed one-half the depth of beam and that of inclined members shall not exceed three-fourths of the depth of beam. It may be assumed that all of the external vertical shear in excess of the amount heretofore specified as allowable for concrete is provided for by the steel in vertical or inclined web members and bent-up bars.

Web members, such as stirrups, when not rigidly attached to the longitudinal steel at both top and bottom, shall be carried around and bent over the longitudinal members or otherwise sufficiently anchored in the compression concrete to develop the tensile stresses existing in them. Web members shall be rigidly attached to the

longitudinal steel on the tension side. Stirrups at the ends of continuous girders shall be inverted with the free ends anchored in the compression concrete at the bottom of the beam. The length of stirrups or diagonals embedded in compression concrete shall be sufficient to develop their entire tensile stresses by adhesion.

Columns.—The length of columns shall be taken as the maximum unsupported length.

The unsupported length of columns shall not exceed 15 times the effective diameter or least effective thickness when longitudinally reinforced nor 10 times the effective diameter for hooped columns, and in no case shall the effective diameter or least effective thickness be less than 9 ins., measured within the ties or hooping from out to out of the longitudinal reinforcement. The length shall include any corbel or knee brace attached to the column. The effective diameter of columns supporting girdless floors shall be not less than one-twelfth the least panel dimension of panels supported by any column.

Bending stresses in columns due to eccentric loads shall be provided for by increasing the section of concrete or steel so that the total unit stress shall not exceed the allowable working stress in flexure.

Suitable steel base plates or castings shall be provided at the bottom of columns to distribute the loads over the footings, and the vertical reinforcement bars shall bear squarely on these plates or the reinforcing bars shall be carried down into an enlarged footing to distribute the load through bond stress.

In columns where necessary to splice vertical bars having areas in excess of 1¼ sq. ins., it shall be done by cutting the bars squarely at the ends and enclosing them in a close-fitting pipe sleeve, or uniting them by a threaded splice or other mechanical connection that will transfer the load from one to the other without stressing the adjoining concrete excessively. The middle point of such splices shall be within 1 ft. above the floor level. Splices in column hooping where necessary shall be sufficient to develop the full strength of the hooping.

All interior columns shall be round. When interior columns other than round are used for architectural effect, the corners shall be made of plaster on metal lath built around the columns after they are fully set.

Longitudinally reinforced columns shall have not less than 4 vertical bars or rods secured against lateral displacement by steel ties placed not farther apart than 16 diameters of the vertical bars or rods, nor more than 12 ins. The area of the vertical reinforcement shall be not less than 1 per cent. nor more than 4 per cent. calculated upon the effective area of the column, which is the area within the reinforcement. No vertical bars shall have a diameter or least dimension less than ⅝ in. and steel ties shall be not less than ¼ in. in diameter or least dimension.

Hooped columns shall be reinforced with vertical steel with an area of not less than 1 per cent. and not more than 4 per cent., calculated upon the effective area of the column. The vertical bars or rods shall be spaced not farther apart than one-eighth the circumference nor more than 8 ins., and be secured to the hooping. The reinforcement, in the form of hoops or spirals, shall be not less than 1 per cent. (that is, a volume of steel equal to the required per cent. of the volume of concrete within the hoops or spirals for a unit length of column), with a clear spacing not greater than one-sixth the effective diameter, and preferably not greater than one-tenth the effective diameter, nor more than 2½ ins. For hooped columns reinforced as herein specified, the unit concrete stresses may be 700 lbs. per square inch for 1 : 2 : 4 concrete and 870 lbs. per square inch for 1 : 1½ : 3 concrete.

The load which may be carried by any column shall be determined by the following formula:—

$$P = f_o (A_o + nA_s).$$

in which:

P = total load in pounds.
f_o = allowable compressive fibre stress in pounds per square inch on the concrete.
A_o = effective area of concrete in square inches.
n = ratio of deformation.
A_s = area of vertical steel in square inches.

Axial compression in structural steel columns thoroughly encased in concrete having a minimum thickness of 4 ins. and reinforced with not less than 1 per cent. of hooping steel (that is, a volume of steel equal to 1 per cent. of the volume of concrete within the hoops), equally divided between vertical reinforcement and spirals or hoops spaced not more than 12 ins. apart, may be taken at 16,000 lbs. per square inch on the net section of the structural steel, no allowance being made for the concrete casing. The spirals or hoops shall be placed not nearer than 1 in. from surface of the concrete. The ratio of length to least radius of gyration of the structural steel section shall not exceed 120.

Walls.—Exterior and interior bearing and non-bearing walls of reinforced concrete shall be securely anchored to all intersecting walls, columns and floors, and the allowable compressive stress shall not exceed 250 lbs. per square inch. The thickness shall be not less than two-thirds that specified for brick walls, and in no case less than 8 ins. All such walls shall be reinforced with steel running both horizontally and vertically. The amount of reinforcement shall be not less than one-fifth of 1 per cent. of the cross-section of the wall, and shall be equally disposed near each face of the wall; except that in walls or partitions 8 ins. or less in thickness, the reinforcement may be placed as a single layer in the middle. Reinforcement shall be spaced not more than 18 ins. apart. Additional reinforcement shall be placed around wall openings, and all vertical and horizontal reinforcement shall be wired or have other mechanical bond at intervals not exceeding 18 ins. in either direction.

General.—The 1916 Report of the Joint Committee on Concrete and Reinforced Concrete shall be followed in the design of girderless slabs, and it shall be the final authority in interpreting these specifications and applying same to unusual cases of spans and loading.

PRODUCTION OF SCHEELITE IN NEW ZEALAND.

Scheelite is found in several sections of New Zealand in the neighborhood of the gold mines both in the North and South Island, and has of late been quite extensively mined. The output has increased from 58 long tons, valued at $20,746, in 1909, to 130 tons, valued at $64,953, in 1912, and to 194 tons, valued at $135,211, in 1915.

Since September, 1915, the British government has requisitioned all supplies of scheelite and other ore containing tungstic acid, and from that date all exports to other markets have been prohibited. The price fixed by the Imperial Government was £2 15s. ($13.38) per unit (a unit being 1 per cent. of tungstic acid in the sample) delivered at London or Liverpool, the scheelite concentrate to contain not less than 65 per cent. (65 units of tungstic acid).

It was reported in the latter part of 1915 that a large body of scheelite was located in the eastern part of the North Island in the Hawke's Bay district.

DIAGRAMS FOR THERMAL CORRECTIONS FOR ROAD OIL AND FOR CONTENTS OF TANKS.

The specifications of the Road Department of Los Angeles County, California, for road oil for macadam contain the following clause for thermal corrections:—

For the purpose of measuring this oil, a temperature of 60° F. shall be deemed normal temperature.

The accompanying diagram was devised by E. Earl Glass, of the Road Department, for applying the thermal correction. The following example illustrates the method: A tank received measures 1,100 gallons of oil at 375° F.

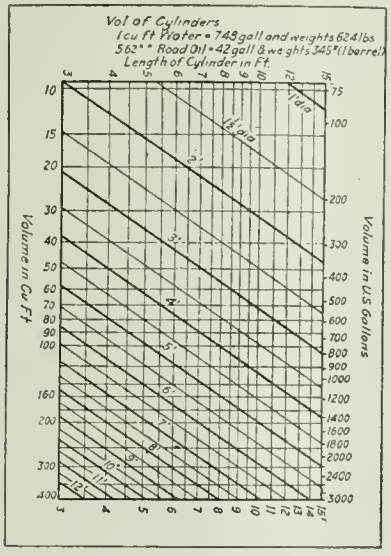

Vol of Cylinders
1 cu ft Water = 7.48 gall and weights 62.4 lbs.
.562 " Road Oil = 4.2 gall & weights 345 " (1 barrel)
Length of Cylinder in Ft.
Volume in Cu Ft
Volume in U.S Gallons

Diagram for Finding Contents of Tank.

The slant line 1,100 gallons hot oil intersects the 375° vertical line at 995 gallons, which would be the 60° F. volume of the load. The chart is used by the inspectors on road oiling.

The other diagram, also devised by Mr. Glass, is used for finding the contents of all ordinary sized tanks used in road oiling.

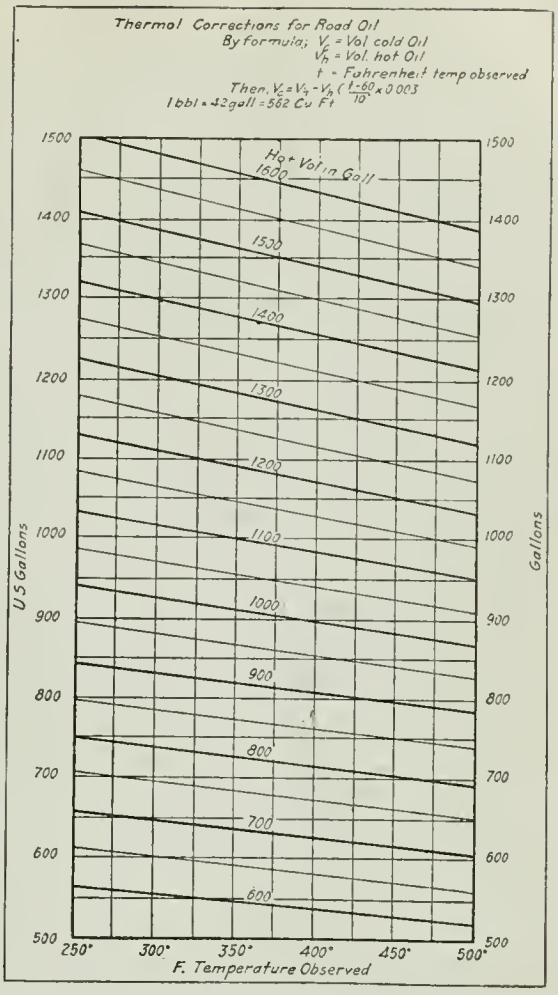

Thermal Corrections for Road Oil
By formula; V_c = Vol cold Oil
V_h = Vol. hot Oil
t = Fahrenheit temp observed
Then, $V_c = V_h - V_h \left(\frac{t-60}{10} \times 0.003\right)$
1 bbl = 42 gall = 5.62 Cu Ft
H_0 = Vol in Gall
U.S Gallons
Gallons
F. Temperature Observed

Diagram for Determining Thermal Corrections for Road Oil.

In determining the quantity of oil delivered, the correction for expansion by heat shall be as follows:—

From the measured volume of oil received at any temperature above 60° F. an amount equivalent to 0.3 of 1 per cent. for every 10° above said 60° F. shall be subtracted as the correction for expansion by heat.

JAPAN'S BOOM IN METALS.

The total value of the mineral output in Japan in 1915 was $87,711,075. exclusive of the production of the government iron works. This was a gain of $10,428,620 over 1914. The total value of metals produced amounted to $17,811,405, or 57 per cent. above the previous year's figures. The increase in copper output was 7 per cent., and in value more than 37 per cent. over 1914. Antimony output increased 200 per cent., while the gain in value was 8,750 per cent. Zinc showed an advance of 206 per cent. in output and 804 per cent. in value.

In Java Dutch government engineers have built a road bridge more than 100 feet long and with a central span of more than sixty feet entirely of bamboo.

The exports of coal from the United Kingdom in the 10 months ended October 31 last year were 32,741,158 tons, as compared with 36,944,758 tons in the first 10 months of 1915, and 52,060,846 tons in the first 10 months of 1914. These totals were increased to 35,150,172 tons, 38,830,606 tons and 54,523,993 tons by the addition of coke and patent fuel. The exports of bunker coal to October 31 were 10,960,984 tons, as compared with 11,745,472 tons and 16,037,409 tons. It will be seen that the coal exports have fallen off very decidedly when compared with 1914, and that a moderate further decline had occurred as compared with 1915.

FERRO-PRODUCTS.

Ferro-silicon and ferro-phosphorus were produced in Canada in electric smelting plants during 1915, the latter in small quantites only. Ferro-silicon, 50 per cent., 75 per cent., and 85 per cent., was made at Welland, Ont., by the Electro-Metals, Limited, and ferro-phosphorus at Buckingham, Que., by the Electric Reduction Co., Limited.

The total production of ferro-alloys during 1915 was 10,794 tons, valued at $753,404, as against a production of 7,524 tons, valued at $478,355 in 1914, and 8,075 tons, valued at $493,018 in 1913. In 1912 the production was 7,834 short tons, valued at $465,225, and in 1911, 7,507 short tons valued at $376,404.

The total number of locomotives ordered in the United States in the first half of last year was 2,124, while orders for 878 more were booked in the four months ending October 31. The year's aggregate was thus carried to 3,002 engines. The number of locomotives for which contracts were let in October was 386; of these 173 were ordered by foreign buyers.

$60,000,000 worth of construction during the next four years on extensions of the steel plant at Steelton, Pa., and Sparrows Point, Md., is announced by the Bethlehem Steel Co., which will build new blast furnaces, steel mills, and other important plant involving much construction work such as grading, foundations, steel-work, concrete.

LETTER TO THE EDITOR.

Re Design of Steel Stacks.

Sir,—In reply to a letter written by Mr. W. A. Hitchcock, assistant professor of civil engineering, University of Wyoming, which you published under the above heading in your issue of December 14th, the writer wishes to offer the following. That the statements here presented may be the more readily connected with the letter it is considered paragraph by paragraph.

The undersigned in his letter (published November 16th) re the original article, did not state that the designing curves were convenient and correct. The statement was made that the results given in the curves for "minimum thickness of plates" (i.e., Figs. 2 and 3), was in a convenient form for use and referred to these curves only. The writer's former letter was quite clear, that the curves for the coefficients C_1 and C_2, as published in Fig. 5, gave incorrect results.

Mr. Hitchcock acknowledges two numerical errors but as he omits to mention which two, it is impossible to check his statement that they do not occur in any of the first solutions which he now calls his "preferred" solutions. There was nothing in his original article to state that he considered them "preferred" at the time it was written. The "preferred" solution for the size of anchors, i.e., the first solution, does, however, contain errors which were pointed out in the writer's original letter and these errors include an incorrect assumption on which the solution is based and a numerical error in deriving Equation (29) from (28). The most vital errors in the original article, as pointed out in the writer's former letter, were not the numerical errors but the errors in assumptions and application of theory. The opening paragraph of the original article stated that some of the formulæ were new and that all diagrams were new. The undersigned did not, as Mr. Hitchcock would have us believe, state that nothing new had been given but that the article contained nothing new except the diagrams and the incorrect conclusions based on the errors. These incorrect assumptions may have "long been used by other designers," but this cannot be considered a reason for their preservation.

There was no intention to add another to the solutions given by anchor bolt sizes. The assumptions used in solutions (1) and (2) have been shown in the former letter to be untrue and results therefore incorrect. The assumption which the present writer substituted and which has not yet been proved wrong, shows, as was intended, that a solution along the lines followed in (1) and (2), if correct and if accurately applied, would give the same results as solution (3) when correctly calculated. Solution (3) should probably be considered the "preferred" solution, since it has the advantage of being based on a correct assumption, but even here, because of error in Equation (40), the result was incorrect. It cannot be considered a case of choosing, or trimming down, the design; the sizes used are chosen after the size, theoretically required, has been calculated. All theoretical solutions based on correct assumptions will, if accurately applied, give the same result.

The statement in the writer's letter regarding the comparison of solutions (1), (2) and (3) was not, as Mr. Hitchcock states, an error. There is, as was stated, no evidence in his article as to why he decides that solutions (1) and (3) give too high results and (2) too low, unless we consider the effect of the errors. If this is considered, the evidence is clear because the errors have had the effect of increasing sizes obtained by (1) and (3) and decreasing those derived in (2). This applies equally well to the specific problem of 12 bolts or to any other case.

The "apparent" error in Equation (44) is a real one. It is not a case for the designer to choose, but is the question of calculating correctly the stress per lineal inch along the circumference, at the base plate. The writer's Equation (44a) gives the correct result, while the original Equation (44) does not.

The author states that the fallacies of the original assumptions are admitted by all. If this had been stated in the original article or, better still, if the solutions based on these false assumptions had been omitted, the writer's original letter would have been unnecessary. It is not a question of the results being safe or unsafe but a question of obtaining accurate results. These, as set forth in the writer's former letter, have not yet been disproved, and to this letter those interested are referred.

H. M. WHITE,
Designing Office,
Dominion Bridge Co., Ltd.,
Montreal, Canada.

Montreal, December 27, 1916.

RUSSIAN GOVERNMENT OFFICIALS DESIRE INFORMATION REGARDING CANADIAN FACILITIES FOR WATER POWER DEVELOPMENT.

As a result of the campaign which the Dominion Water Power Branch of the Department of the Interior has been carrying on for some months, to make known throughout the allied countries the Canadian water power situation, there has been received an urgent request from Russia for some detailed information regarding facilities available in Canada which might be used in Russia for carrying out some very extensive hydro-electric power schemes now under consideration in that country.

The Dominion Water Power Branch has been asked to furnish information respecting Canadian engineering experience in the design and construction of hydro-electric developments, also regarding Canadian manufacturers of all kinds of equipment, electrical, hydro-electric and mechanical, required for a complete water power project. While every effort will be made by the Dominion Water Power Branch officials to secure this information direct, *The Canadian Engineer* has been asked to call the situation to the attention of its readers, in order that any one interested in furnishing the necessary information to Russia may be advised of the situation and communicate direct with the superintendent of that branch in Ottawa.

The secretary of the Canadian Society of Civil Engineers, Montreal, has been requested to furnish as complete a list as possible of the Canadian engineers who have had experience in the design and construction of our water power developments.

The iron ore exports from Algeria during the first nine months of the present year totalled 739,288 tons, as compared with 625,912 tons during the corresponding period of 1915.

Topographic surveys by the United States Geological Survey have now covered 41 per cent. of the entire area of the country, according to the annual report of Secretary Lane, of the Department of the Interior. During the year ending June 30, 1916, 22,715 square miles were mapped topographically, making the total area in the United States surveyed to date 1,237,520 square miles. Topographic surveys were made in 29 states, 17 of which co-operated in the work. In the Division of Water Resources 1,302 river gauging stations were maintained in 1916.

SLAB DEFLECTION AND SUBSIDENCE OF COLUMN SUPPORTS IN A FLOOR TEST OF INTERNATIONAL HALL, CHICAGO.*

By Henry T. Eddy, C.E., Ph.D., LL.D.,
University of Minnesota.

REINFORCED concrete floor slabs are somewhat imperfectly elastic, and in testing them an allowance is commonly made for this fact by the requirement that in case of any excessive deflection at least 80 per cent. of it shall disappear within a week after the removal of the load which produced the deflection. This requirement recognizes the imperfection of the elastic properties of the slab in two ways, since first, it does not forbid some residual permanent deflection, and, further, it does not require immediate recovery, neither of which concessions could be made in case of a perfectly elastic structure.

Few materials of construction are so perfectly elastic as actually to make an immediate and complete recovery, but a much larger margin is allowed to reinforced concrete than to most other materials. It should be noticed that on account of its being a composite structure, composed partly of steel and partly of concrete, of which the steel is more nearly perfectly elastic than the concrete, a floor slab with steel massed in the column heads will have a more prompt and complete recovery than one with so-called drop heads of concrete in place of the heavy reinforcement in the column heads.

But in the retardation or time lag of slab recovery a phenomenon is exhibited which is not found to any perceptible extent in other kinds of materials of construction in ordinary use. Since recovery from slab deflection is gradual and may never be complete, and since a corresponding gradual increase of deflection must occur under a load, it has been argued by some that final stability under a load is impossible. The permanence, however, of ancient concrete structures seems to show that there must be a limit to the deformations and deflections that will take place under loads, just as there is to the recovery after removal, and it must be admitted that concrete is not really plastic, although the property of concrete to which attention has just been directed bears some of the marks of plasticity. Were concrete really plastic under ordinary stresses, that fact would spell the ultimate destruction of buildings and bridges made of that material. But concrete is a kind of artificial rock and evidently reaches, in time, a permanent and invariable state in which progressive changes no longer take place, although, in course of hardening, phenomena may occur which, if not ultimately checked, would involve final collapse.

Now, the theory of the flexure of slabs differs from that of continuous beams in important particulars, one of which is that the applied moments and the observed resisting moments are not equal to each other, a fact the reasons for which are discussed elsewhere. But to this fact it is due that the economical and safe depth or thickness of slabs for any given span is small compared with that of beams, a fact which partially obviates one of the great drawbacks that exists to the use of continuous beams, *viz.*, the large stresses introduced by any accidental subsidence of supports.

As just stated, one of the most serious practical objections to the employment of continuous beams lies in the very large stresses induced by settlement of supports, because this will usually entirely disarrange the stresses for which the structure was designed. This hazard has operated very largely to prevent the construction of continuous bridges consisting of several successive spans. But a subsidence of a magnitude which might produce dangerous stresses in a structural steel building may be taken up in course of construction in a reinforced concrete building without requiring special attention, since the relatively large flexibility of these slabs is such as to make the effects of moderate subsidences inconsiderable compared with the effects of subsidences of the same absolute amount in bridges and deep girders.

The structural utility of continuous panels is so great as to outweigh their risks and practically to necessitate their adoption. The fact previously stated that the applied moments and resisting moments in slabs are unequal does not, however, prevent us from applying the theory of flexure to slabs as well as to beams, although it does prevent us from calculating the moment of inertia of the resisting materials in slabs in the same manner as in beams. But those deductions from the theory of flexure which are independent of the magnitude of the moment inertia are valid equally for beams and for slabs. Such, for example, are the relative deflections and vertical displacements of different points in the span. This it is which has made it possible to treat with success an important question which arose in the discussion of the test of the floor of International Hall.

In this floor slab the foundations of the columns proved insufficient to carry the test loads without yielding by amounts large enough to have considerable effects upon the stresses and deflections of the four loaded panels, each of which was 18 by 18 feet square. The floor as tested was a deck slab with no columns on its upper side. It was three panels wide and nine panels long, and was built into the surrounding walls of an old brick building by cutting into them somewhat for space to place steel and pour concrete, so that the edges of the slab were made integral so far as possible with the walls. The four panels which were tested formed a square near the middle of one side of the slab, two of them being in one tier of wall panels and the other two in the middle tier adjacent to them. In this floor, with its two rows of supporting columns parallel to the long sides of the building, certain vertical displacements were measured at the columns and at mid-span between columns and walls, both before and a week after the removal of the final test load, and the question was to determine whether the recovery was as much as 80 per cent. of the maximum deflection, and so whether there still remained as much as 20 per cent. of the maximum. The solution of this problem implicitly requires the determination of the magnitude of the vertical displacements which would occur in the slab by reason of the subsidences of the column supports only; for the actual vertical displacement at any point of the slab is the sum of two kinds of displacement; first, that due to the bending by reason of subsidence of the points of support, and, second, that due to bending by reason of the applied load. The fact that the subsidence of columns was itself also due to the applied load is immaterial, since the effect would be the same were the subsidence due to some other cause.

When that part of the vertical displacement at any point which is due to the subsidence of supports is subtracted from the actual vertical displacement observed at that point, the remainder is the true deflection and may be either that due to the effect of the load in bending the slab or to the residual bending effect after removing the load, according as the load is still resting upon the slab

*Journal of Franklin Institute.

or has been removed. The ratio of the remainder after removal to the remainder before removal will show how much the recovery falls short of being complete.

Let these four panels be designated by A, B, C, D, respectively, as shown in Fig. 1, with columns numbered from 1 to 6. Panel B is the centre of the entire floor. Let the reinforced direct belts extending across the slab over the columns be regarded as continuous beams fixed horizontally at the walls. The assumption that they are fixed at the walls is probably not entirely correct, but more nearly so than the assumption of mere support at the walls. It is found that the latter assumption gives results which do not differ much from those obtained by assuming the ends to be fixed in direction as well as position. If L be taken as the distance between successive columns, these belts or beam strips, which may be taken roughly as having a width of 0.5 L, are not of uniform moment of inertia throughout their lengths, but will, for the purpose of preliminary investigation, be assumed as uniform, and their irregularity of cross-section will be allowed for later.

Given a uniform continuous beam of three equal spans, each of length L, as shown in Fig. 2, whose extremities are fixed horizontally on the same level, but whose intermediate points of support at points 1 and 2 are depressed by the observed subsidence z_1 and z_2, respectively, below the level of the extremities, to find the displacements z_{12}, z_{01}, z_{23}, at the middle of the centre and end spans respectively, there being no stresses or displacements due to any other cause than the subsidences z_1 and z_2.

Let M_0 and M_3 be the moments at the extremities and M_1 and M_2 at the intermediate supports, respectively.

Then, by making use of the theorem of three moments, which applies in its general form to any two successive spans of a straight beam with supports at any arbitrary levels, we have the following four equations by taking four successive pairs of spans, as follows: The first pair, Equation (1), consists of a span of zero length and a span extending from the wall at 0 to the first row of columns

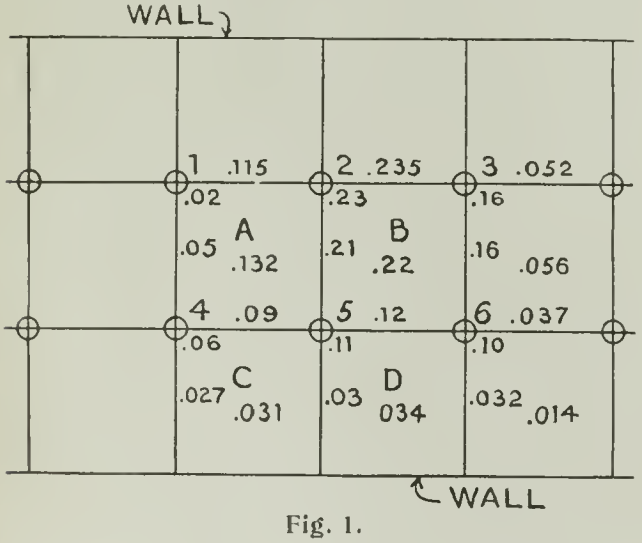


Fig. 1.

at 1. The effect of a span of zero length is to give the slab a fixed horizontal direction at the wall. The second pair of spans, Equation (2), extends from the wall at 0 to the first row of columns and from the first to the second row of columns at 2. The third pair, Equation (3), extends from the first row of columns at 1, across the second row to the other wall at 3, and the fourth pair, Equation (4), from the second row of columns at 2, to the second wall at 3, and includes a span of zero length at that wall.

The notation may be understood from Fig. 2, in which the tangents at the 0 and 3 are fixed in a horizontal position and the vertical displacements or subsidences at

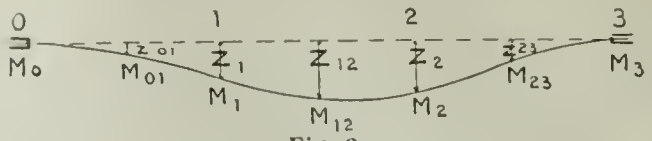


Fig. 2.

the intermediate supports 1 and 2 are of known amounts, z_1 and z_2, and the vertical displacements at mid-span are designated by z_{01}, z_{12}, and z_{23}, respectively, while the applied bending moments are denoted by the letter M with corresponding subscripts, and the length of the equal spans between supports by L.

$$6\,EIz_1 = (2M_0 + M_1)\,L^2 \quad \ldots\ldots(1)$$
$$-6\,EI\,(2z_1 - z_2) = (M_0 + 4M_1 + M_2)\,L^2 \quad \ldots\ldots(2)$$
$$6\,EI\,(z_1 - 2z_2) = (M_1 + 4M_2 + M_3)\,L^2 \quad \ldots\ldots(3)$$
$$6\,EIz_2 = (M_2 + 2M_3)\,L^2 \quad \ldots\ldots(4)$$

Considering now the mid-displacement z_{12} of the middle span 12, it may be expressed in terms of the two end moments and end displacements of that span as follows:—

$$6\,EI\,(z_1 + z_2 - 2z_{12}) = \tfrac{3}{4}\,(M_1 + M_2)\,L^2 \quad \ldots\ldots(5)$$

as appears from the fundamental equation of moments and shears used in establishing the equation of three moments.

The solution of these five simultaneous linear equations by the method of indeterminate multipliers or otherwise gives as a result

$$z_{12} = 5/8\,(z_1 + z_2) \quad \ldots\ldots(6)$$

A similar consideration of the mid-displacement z_{23} of the end span 23 shows that

$$6\,EIz_{23} = 1/8\,(M_2 + 5M_3)\,L^2 \quad \ldots\ldots(7)$$

The solution of the first four simultaneous linear equations and (7) gives

$$z_{23} = (19z_2 - 4z_1)/40 \quad \ldots\ldots(8)$$

and by symmetry

$$z_{01} = (19z_1 - 4z_2)/40 \quad \ldots\ldots(9)$$

Hence

$$z_{01} + z_{12} + z_{23} = z_1 + z_2 \quad \ldots\ldots(10)$$

which is a fundamental equation of displacements in this case of no loads.

In case the assumption were that the walls are simple supports and exert no restraint, the values of the displacements at mid-span have been found to be

$$\left.\begin{aligned} z_{12} &= 23\,(z_1 + z_2)/40 \\ z_{23} &= (29z_2 - 6z_1)/40 \\ z_{01} &= (29z_1 - 6z_2)/40 \end{aligned}\right\} \quad \ldots\ldots(11)$$

from which it appears that this would make the displacement at mid-span of the middle span a little less and at mid-span of the end spans a little greater than when the ends are fixed, and the same kind of effect, but of smaller amount, will be produced by any relaxation of fixity at the walls.

It will be noticed from (11) that

$$z_{12} = z_{01} + z_{23}$$

It is evident that the floor under consideration may be taken to consist of beam strips not only crosswise from side wall to side wall, as has just been done, but also as made up of beam strips parallel to the side walls and extending lengthwise of the building, and that the agree-

ment of the results of computations by these two methods will tend to establish their correctness. Suppose the beam strips to each have a width of $\frac{1}{2}L$ extending over the two rows of columns parallel to the long side walls, with a strip of the same width lying between these two. If the length of these strips be taken as $4L$, they may be assumed to have their ends practically fixed horizontally, with certain observed vertical displacements at the three intervening columns. The problem in this case is this: Given the vertical displacements z_1, z_2, and z_3 at points of support 1, 2, and 3 of a beam fixed horizontally at the ends 0 and 4, to find the vertical displacements z_{01}, z_{12} z_{23}, and z_{34}, at mid-span between each pair of supports. The equations are like those already used in the case of three spans, and the values arrived at in the same manner are:—

$$\left.\begin{aligned} z_{01} &= (106z_1 - 21z_2 + 6z_3)/224 \\ z_{12} &= (142z_1 + 133z_2 - 30z_3)/224 \\ z_{23} &= (142z_3 + 133z_2 - 30z_1)/224 \\ z_{31} &= (106z_3 - 21z_2 + 6z_1)/224 \end{aligned}\right\} \quad \ldots\ldots\ldots (12)$$

It will be noticed that in this case

$$z_{01} + z_{12} + z_{23} + z_{34} = z_1 + z_2 + z_3 \quad \ldots\ldots\ldots (13)$$

which is an equation of deflections for four spans similar to (10) for three spans.

On Fig. 1, which shows a plan of the panels of the test, are inscribed, at columns 1 to 6, the amounts of the vertical displacements observed under the final load in inches, and at mid-span between these columns the vertical displacements, computed according to the foregoing equations, that would take place in a uniform slab by reason of the displacements at the columns without applying any load to the slab except the reactions at the columns which are necessary to produce the displacements at the columns.

Displacements at panel centres are also given. These last are computed both by taking beam strips crosswise and lengthwise of the floor midway between the beam strips already computed across the tops of the columns. Practically the same values at panel centres are obtained from the computation by strips crosswise as lengthwise. This affords a satisfactory check on the work. Were the slab of uniform moment of inertia throughout, the displacements which have been computed at mid-spans and panel centres would express the position of the surface from which true deflections should be measured, or the surface of zero deflection from which deflections due to the load or lack of recovery are to be measured. That, however, is not entirely correct for a floor slab, by reason of the great relative stiffness and extent of the column heads, which must be allowed for. The side belts are weaker near mid-span than elsewhere. The kind of effect that this produces may be made evident by considering what would be the effect of joints at mid-span of the beam strips across the floor. That would cause angles in the strips at each mid-span with comparatively straight portions over the columns. At mid-span in the centre of the strip the displacement would evidently be increased by such joints or by any weakness of this kind. In the case of the test under consideration it is estimated that the combination of a central conduit in each panel tier parallel to the long side walls, with the lack of columns integral with the slab above it, added not less than 25 per cent. to the computed vertical displacements at the centres of panels *A* and *B* and midway between those points, these being the points of maximum deflection at which the percentage of recovery is to be determined.

The accompanying table gives in column 1 the computed vertical displacements at these points, and in column 2 these amounts increased by 25 per cent., to take account of the increased displacement by reason of lack of uniformity in the slab. Column 3 gives the observed displacements under maximum load, and column 4 the observed displacement after removal of the load and recovery. Column 5 is the difference between column 3 and column 2, or the deflection under the load. Column 6 is the difference between column 4 and column 2, or the deflection after removal of load and recovery. Column 7 is the ratio of column 6 to column 5, or the percentage which the residual deflection is of the maximum. Column 8 is 100 per cent. less the per cent. in column 7, or the percentage of recovery, which has a mean value of 80.7.

Table of Vertical Displacements and Deflections in Inches.

At centre of	1 Computed for uniform slab.	2 Increased 25 per cent. not uniform.	3 Maximum observed displacement.	4 Minimum observed displacement.	5 Maximum deflection column 3 less column 2.	6 Minimum deflection column 4 less column 2.	7 Percentage of residual deflection.	8 Percentage of recovery.
Panel A.....	0.13	0.16	1.04	0.38	0.88	0.22	25	75
Span 2—5.....	.21	.25	.95	.37	.70	.12	17	85
Panel B.....	.22	.264	.98	.38	.716	.116	16	84
Mean	0.19	0.225	0.99	0.38	0.765	0.152	19.3	80.7

The application of a rule requiring a recovery of 80 per cent. in this case, however, discriminates against the floor structure and attempts to have it make good the shortcomings of the faulty foundations on which the columns rest. At the time of the maximum load, when subsidence of the columns took place, the columns were subjected to a very considerable bending moment by reason of the tipping of the floor, which was integral with the column heads. This caused the foundation of each column not only to sink vertically, but to tilt at the same time in an inelastic displacement. On removal of the load, any restoration of the foundation either to its original vertical position or level would have to be accomplished, not by any elastic effort of the foundation itself, but by an elastic effort coming from the floor itself. Not only was work required to displace the foundation at first, but additional work will be required after the removal of the load to right the foundation, or else the foundation will itself tend to restrain the slab and hold it in its displaced position not merely by reason of its vertical displacement, but by reason of its tilted position in addition to that. Thus it is that the displaced foundations tend to prevent the recovery of the slab in other ways than merely by the vertical displacements which have been considered in the preceding computations.

CUBAN MANGANESE INDUSTRY.

The United States Consul reports that the manganese industry of Cuba, which dates back about twenty years, has been continued, with certain interruptions, up to the present time. There are within the Santiago district three generally recognized deposits of ore known as Cristo, Cauto and Ponupo, the last-mentioned being the largest, and having produced up to the present about 2,000,000 tons. It is still producing about 3,000 tons per month of a fair grade of furnace ore averaging about 43 per cent. metallic content. The Cristo group is producing a small amount of ore that runs about 46 per cent., while the Cauto group is producing about 2,000 tons per month. During 1915 practically all the ore produced was shipped to Baltimore, with the exception of a small consignment to Italy. The demand for furnace ore is still strong. None of the ore is treated locally, except by washing to remove the dirt. Large deposits of manganese still remain undeveloped, no particular attention having been given to them.

TRACTIVE RESISTANCE TESTS WITH AN ELECTRIC MOTOR TRUCK.

THE Research Division of the Electrical Engineering Department of the Massachusetts Institute of Technology during 1915 conducted an investigation of tractive resistance of urban roads to a motor delivery wagon equipped with solid rubber tires. The results of the tests are described in a recently issued bulletin, from which the matter that follows is taken.

The subject of the research was to determine the resistance, including air resistance, offered to an electric truck, by level urban roads of different surface varieties, at standard truck speeds not exceeding 25 km. (15.5 miles) per hour. For this purpose, the output of the storage battery on a test truck was measured, for both directions of travel, over standard road beds, at different controller speeds. From this output were deducted all the corresponding electrical and mechanical losses in the truck mechanism, as determined by laboratory tests. The remainder of the output was consequently attributed to (1)

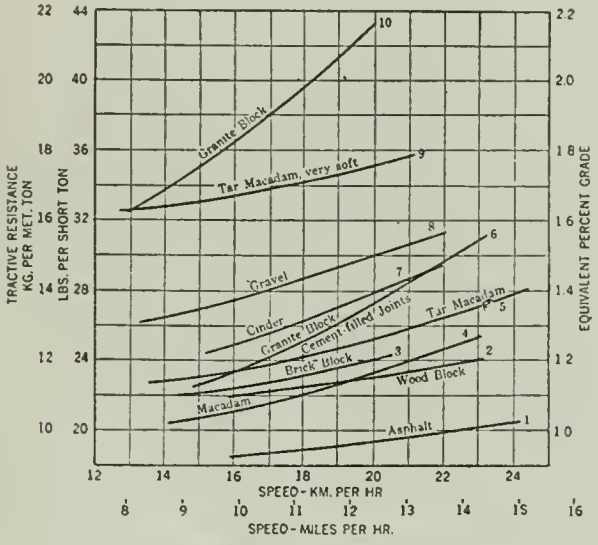


Fig. 1.—Summary of Tractive Resistance Tests.

road- (2) air- and (3) wind-resistance. The wind resistance was eliminated by averaging the results for both directions of running, leaving as the final result the sum of the road and air resistances.

By "road resistance" is meant the horizontal force required to pull the truck, assumed as internally frictionless, over the horizontal road in the absence of air. By "air resistance" is meant the horizontal force on the truck required to overcome the resistance of the air, assumed as quiescent in the absence of the truck. By "wind resistance" is meant the horizontal force on the truck necessary to overcome the resistance of the wind velocity, or that velocity of the air with respect to the ground which exists in the absence of the truck.

A 1,000-lb. (450-kg.) worm-drive, single-reduction electric truck, or delivery wagon, was placed at the disposal of the Research Division for the purpose of test. Its specifications are as follow:

Load capacity, 1,000 lbs. (450 kg.), equipped with one d.c. series motor; overall length of frame, 4,280 mm. 168½ ins.; width of frame, 890 mm. 35 ins.; wheel base (i.e., distance between centres of front and rear wheels, when front and rear axles are parallel), 2,730 mm. 107⅝ ins.; wheel gauge, 1,470 mm. 58 ins.

The total weight of the truck, including motor, battery and body, but without load or passengers, was 4,200 lbs. (1,910 kg.). Each of the four wheels was equipped with one solid rubber demountable tire (manufactured for this type of delivery wagon) rated at 36 ins. by 2½ ins. (91.5 c.m. by 6.35 c.m.), and actually measuring about 35 ins. (89 c.m.) tread diameter, and 2½ ins. (6.35 c.m.) width of base. The brakes were of the internal expanding type on each rear wheel.

Typical results for all classes of urban roads tested are summarized graphically in Fig. 1, and numerically in Table 1. It appears that there are three principal elements which determine the tractive-resistance-speed curve for unit weight of a given vehicle, within the range of conditions covered by this test:

(1) A constant resistance, see curve 1, Fig. 2; the magnitude A of which depends on the lack of resilience of the road surface and wheel tire material, i.e., on the energy losses due to displacement of tire material and road-surface material. This constant element A would be encountered upon a smooth level road of the particular type considered, in the absence of impact, air, and wind resistances.

(2) An increasing resistance with increasing speed, due to impact losses (curve 2), which results from lack of smoothness of road surface; losses of this nature are usually known to vary approximately as the second power of the velocity at impact; and

(3) An increasing resistance with increased speed, due to air pressure against the front of the vehicle, curve 3, which resistance is known to depend, roughly, on the second power of the speed. The sum of the three curves for items 1, 2 and 3, for the case of asphalt roads, results in curve 4. The constant resistance (1) may be briefly called the displacement resistance, item 2 the impact resistance, and item 3 the air resistance. The displacement resistance is low for hard pavements and high for soft pavements (of low resilience). The impact resistance is very marked in granite-block roads, as already mentioned. The air resistance, at any definite velocity, is the same for all curves; because the air-resisting parts of the truck were left unchanged throughout the tests. For an asphalt road in poor condition, at a speed of 20 km. per hour (12.4 miles per hour) the displacement resistance is 0.84 per cent., the air resistance is 0.11 per cent., the impact resistance 0.20 per cent. and the total 1.15 per cent. equivalent grade.

The displacement resistance of a road manifestly varies, not only with the type and surface quality of the road, but also with the type, dimensions and quality of the tires on the wheels of the vehicle. In the tests here reported, the same tires were used throughout, and they remained in substantially the same condition.

The impact resistance of a road manifestly depends not only on the type and surface quality of the road, and the sizes of its irregularities; but also on the type, dimensions and quality of the wheel tires, the weight of the truck, and the quality of its springs.

The air resistance per unit weight of truck manifestly depends upon the weight, dimensions and shape of the vehicle, as well as on the speed of the vehicle relatively to the surrounding air.

The wind resistance per unit weight of truck manifestly depends upon the weight, dimensions and shape of the vehicle, as well as on the direction and velocity of the wind and the velocity of the vehicle. It is assumed that at low wind and vehicle speeds, like those here considered, only that component of the wind which is in the direction of the vehicle's path needs to be taken into account, and

that the mean of the wind resistance in opposite directions, along the road, is zero.

Summary of Conclusions.—The following conclusions are indicated from the preceding results: as confined to urban roads, with a solid rubber-tired motor truck between the speed limits of from 13 to 25 kilometers per hour (8 to 15.5 miles per hour).

(1) The over-all efficiency of the test-truck mechanism, as described in this report, between battery terminals and rear-wheel treads, reached a maximum value of about 78 per cent., under the most favorable conditions.

(2) The mechanical efficiency of transmission from motor shaft to rear-wheel treads, for the truck tested, shaft-driven through a single-reduction worm gear, was found as high as 90 per cent.

(3) Tractive resistances are most conveniently expressed as an equivalent percentage grade; i.e., a level road of definite tractive resistance may be regarded as a road of zero tractive resistance, but rising uniformly x units in 100 units of road length, or having an equivalent grade of x per cent.

(4) Under the conditions of these tests, the tractive resistance on level roads, in the absence of wind, is composed of (a) displacement resistance, (b) impact resistance, and (c) air resistance.

(5) The displacement resistance varied from 0.85 per cent. equivalent grade, for a hard, smooth asphalt or bituminous concrete to 1.6 per cent. for a very soft tar-macadam road, and was practically constant, for all speeds considered, on any given road.

(6) The impact resistance increases with the velocity, with the total weight of vehicle, and with increasing road-surface roughness. In these tests, the impact resistance of good asphalt or bitulithic or other smooth pavement, was practically negligible, and reached its highest values on granite-block roads with sand-filled joints, and on badly worn macadam pavements. The rate of increase of impact resistance with speed was most marked on the roughest roads.

(7) At the vehicle speed of 20 km. (12.4 miles) per hour, the air resistance for the vehicle tested, assumed to be dependent only on the speed, was roughly 0.11 per cent. equivalent grade; i.e., from 4 per cent. of the highest, to 12.5 per cent. of the lowest, total tractive resistance.

(8) The following urban pavements are numerated in the order of their desirability for vehicle operation from the point of view of tractive resistance at 20 km. (12.4 miles) per hour, as found in this investigation: (1) asphalt, (2) wood block, (3) hard, smooth macadam, (4) brick block, (5) granite block with cement-filled joints, (6) cinder, (7) gravel, (8) granite block with sand-filled joints.

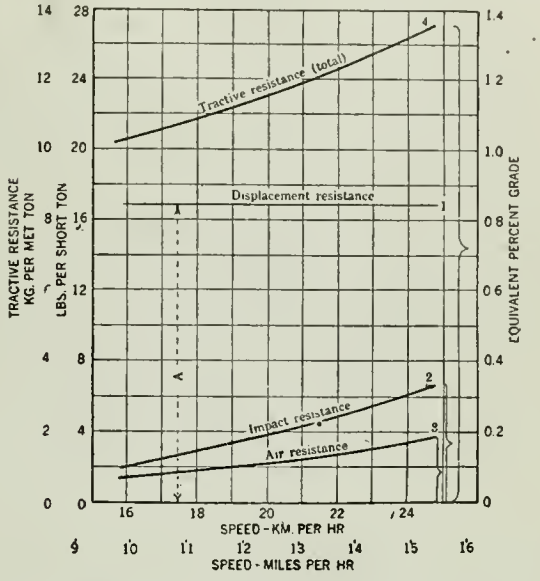


Fig. 2.—Approximate Analysis of Typical Tractive Resistance Into Its Elements for Asphalt Road in Poor Condition.

(9) The equivalent grade at 20 km. (12.4 miles) per hour of a badly worn city macadam road, was found to be nearly three times as great as that of the best asphalt

Table I.—Summary of Tractive Resistances of Different Urban Roads at Different Speeds.

All tractive resistances are expressed in equivalent per cent. grades.

Road. Type.	Condition.	Equivalent per cent grade. at 16 km. per hour (10 miles per hour).	Equivalent per cent grade. at 20 km. per hour (12.4 miles per hour).	Per cent. increase in tractive resistance from 16 to 20 km. per hour.	Comparative tractive resistance factors referred to asphalt roads. at 16 km. per hour.	Comparative tractive resistance factors referred to asphalt roads. at 20 km. per hour.
Asphalt	good	0.93	0.97	4	1.0	1.0
Asphalt	poor	1.03	1.16	11	1.11	1.20
Wood block	good	1.10	1.15	5	1.18	1.18
Brick block	good	1.12	1.21	8	1.20	1.25
Brick block	slightly worn	1.14	1.27	11	1.23	1.31
Granite block	good	1.83	2.16	18	1.97	2.23
Granite block with cement joints	good	1.16	1.37	18	1.25	1.41
Macadam, water bonded	dry and hard	1.06	1.17.	10	1.14	1.20
Macadam, water bonded	fair, heavily oiled	1.63	1.76	8	1.75	1.82
Macadam, water bonded	poor, damp some holes	1.65	1.89	15	1.78	1.95
Tar macadam	good	1.17	1.27	9	1.26	1.31
Tar macadam	very soft	1.67	1.76	5	1.80	1.81
Tar macadam	many holes, extremely poor, soft	2.38	2.75	16	2.55	2.85
Cinder	fair, hard	1.25	1.39	11	1.35	1.43
Gravel	fair, dusty	1.37	1.50	9	1.47	1.55

road tested. This means, at this speed, a consumption of energy at wheel treads, of nearly three times as much on level poor macadam roads as on good level asphalt roads.

(10) Increasing the gross weight of the vehicle by 12 per cent., through load, was found to have no effect on tractive resistance within the observed speed limits for smooth roads in good condition; but on rough roads, a distinct increase in tractive resistance with this extra weight was observed.

(11) The presence of a layer of dust, say, 1 cm. thick, on a fair macadam road, was found to increase the equivalent grade of tractive resistance, at all tested speeds, by about 0.15 per cent.

(12) A freshly tarred and therefore very soft tar-macadam road was found to have an increased tractive resistance equivalent, at substantially all tested speeds, of about 0.5 per cent. The tires in this case sank about 0.8 in. (2 c.m.) into the road-bed, the gross car weight being 2,140 kg. (4,710 lb.).

(13) The total range of tractive resistance equivalent grade covered in the tests, was from 0.93 per cent, on the best asphalt road, at lowest speed, to 2.7 per cent. on the worst macadam road, at nearly the highest speed.

PARTITION OF LOAD IN RIVETED JOINTS.

IN the November issue of the Journal of the Franklin Institute an article appeared written by Cyrol M. Batho, assistant professor of applied mechanics at McGill University, in which he described the theoretical and experimental work carried on there in connection with ascertaining the load carried by each rivet in any form of riveted joint. Experiments were made upon different forms of joints, having a single line of five rivets on each side of the joint, and loaded in tension. The analyses indicated that a series of equations can be obtained giving the load carried by each rivet in any form of riveted joint in terms of a quantity K, which if the results are in shear depends upon the manner in which work is stored in the rivets; or if they act by frictional hold on the plates depends upon the work stored in the parts of the plates so held.

Only the specimen with ½-in. rivets was carried beyond the working load, but the regularity of its action showed that the partition of load obeyed the same laws at all loads up to that causing permanent deformation of the plates or rivets. In every specimen and at all loads the first and fifth rivets took by far the greater part of the total load, the actual proportion decreasing gradually as the load increased. For example, in the specimen with ½-in. rivets, the first and fifth rivets carried 83.5 per cent. of the total load at a load of 10,000 lbs., and this decreased to 70.0 per cent. at a load of 30,000 lbs. The latter load corresponds to an average stress of about 12,650 lbs. per square inch of actual rivet section, or 15,280 lbs. per square inch of nominal rivet section. This would usually be taken as the shearing stress on all the rivets, but actually the end rivets, if, as there seems little doubt, the rivets were in shear and not holding by friction, were each under an average shear stress of 22,150 lbs. per square inch, while the third rivet at the same load took only 3.2 per cent., corresponding to an average shear stress of only 2,020 lbs. per square inch. Thus in joints having several rows each containing an equal number of rivets and designed in the usual manner, i.e., allowing the average load per square inch of rivet section to be equal to the working stress in shear of the rivet material, the rivets in the end rows must carry stresses far above the allowable working stress.

The above refers to the specimens in which the cover plates were of the correct thickness; i.e., each half as thick as the middle plate. If they are thicker, the first rivet takes an even greater proportion of the load, the proportion increasing with increased thickness. In specimen B, in which the cover plates were of correct thickness, the first and fifth rivets took 88.1 per cent. of the load at a load of 16,000 lbs. In specimens D, E and F at the same load they carried 86.2 per cent., 89.7 per cent. and 78.9 per cent. of the total load respectively, but of these the first rivets carried respectively 70.7 per cent., 63.8 per cent. and 50 per cent. of the total load. Specimen F, in which the middle plate was of varying width, illustrated the action in members riveted to a gusset plate, and it was found that the varying width of plate resulted in a rather more even distribution of stress, the first and fifth rivets carrying only 69.7 per cent. of the load, as compared with 78.9 per cent. when the middle plate was cut down to uniform width.

In all the specimens tested the ratio of width of cover plate to pitch of rivets was the same, ¾. K probably varies as the width of cover plate divided by the pitch of the rivets; thus, with a smaller pitch or wider plates, K would be increased, and the effect of this would be to make the partition of the load rather more uniform. But a large variation of K only causes a comparatively small alteration in the percentage of the load carried by the end rivets. For example, in the specimen A a change of K from 0.485 to 1.3 only altered the load carried by each of these rivets from 40.7 per cent. to 35 per cent., and the alteration for a given change becomes less and less as the values of K increase. Thus the effect of change of pitch or breadth of cover is not likely to be very great, except possibly in splices containing a number of rivets in each row. However, further experiments are needed in order that a general law may be found for the value of K. When this is determined it will be possible to predetermine the exact partition of load in any proposed joint, and this will enable the joint to be designed in the most efficient manner. A very good approximation, sufficient for most purposes, may, however, be obtained from the data already given, since the general manner of partition of load is the same for all values of K.

Prof. Batho's summary and conclusions are as follow:—

1. It is shown that a riveted joint may be considered as a statically indeterminate structure, and that a series of equations may be obtained for any joint by means of Principle of Least Work, giving the loads carried by each of the rivets in terms of a quantity K, which depends upon the manner in which work is stored in, or by the action of, the rivets.

2. This theory is applied to various types of joints, and the modifying effects of non-uniform distribution of stress in the plates, unequal partition of the load between the two cover plates, and a difference in the modulus of elasticity of the middle plate and the cover plates are also considered.

3. It is shown experimentally that extensometer measurements on the outer surfaces of the cover plates of a riveted joint are sufficient for the determination of the mean stresses in the plates, and that the partition of the load among the rivets may be determined from such measurements. It is also shown that, at any rate after the first few loadings, the distribution of strain in the plates of a joint is not altered by repeated loadings.

4. It appears from 3 that if there is any frictional hold between the plates, it acts only over those portions in the immediate neighborhood of the rivets. All the experiments tend to show that friction does not play an imporant part, but further experiments are necessary on this point.

5. Experiments made on a number of specimens having a single line of rivets and loaded in tension give results in close agreement with the theoretical considerations. They also show that the longitudinal stresses in a portion of the cover plate between two consecutive rivets are a minimum along the line of rivets, rising to a maximum at the edges of the plates.

6. The experiments show that the value of K for a joint having a given ratio of width of cover plate to rivet pitch and a given number of rivets varies approximately directly as the load and inversely as the area of the rivets. An empirical rule is given for its value in joints similar to the experimental specimens, but a more general rule cannot be given until further experiments have been made. A theoretical estimate is made of the value of K for a rivet acting in shear, and the result is shown to be within the range of the experimental values.

7. Both the experimental results and the theoretical deductions show that: (a) in a double-cover butt joint having a single line of rivets, the two end rivets and the two rivets on each side of the junction of the middle plates take by far the greater part of the load at all loads within that causing permanent deformation of the plates or rivets, the actual proportion decreasing slowly as the load increases; (b) if, in such joints, the total area of cross-section of the cover plates is equal to that of the middle plates, these four rivets take equal loads, but if it is greater the end rivets take greater loads than the others, the difference increasing as the area of the cross-section of the cover plates increases; (c) if two plates of uniform width and equal thickness are connected by a single line of rivets to opposite sides of a gusset plate of uniform width, the first and last rivets take the greater part of the load, but if the gusset plate increases in width from the first to the last rivets, the partition of load is more uniform.

WORLD'S OUTPUT OF GRAPHITE.

Interest in graphite at present is widespread. According to the Canadian Mining Institute Bulletin the two principal forms in which the mineral is found are amorphous and crystalline, the former being very common. The world's production statistics (in tons) for 1912, the latest available, are as follows: Ceylon, 36,660; Canada, 2,060; South Africa, 42; Austria, 50,017; Madagascar, 3,011 United States, 3,835; Mexico, 3,158; Korea and Japan, 8,363; Germany, 13,814; Italy, 14,517; Sweden, 87; Norway, 285; France, 661; total, 136,510.

PAVING EQUIPMENT FOR CUBA.

One of the largest single shipments of paving equipment on record is that just made to Messrs. Torrance and Portal, of Havana, Cuba, who have secured extensive paving contracts for Havana and Cienfuegos.

The shipment made by the Iroquois Works of the Barber Asphalt Paving Company consisted of six cars routed by way of Key West, Florida, carrying two three-unit asphalt plants, two 2,000-gallon and one 1,000-gallon steam-heated melting kettles, four tandem rollers, two portable boilers and engines, fire wagons, paving tools, etc.

Contracts already secured by the Havana firm for paving in which Trinidad lake asphalt will be used total about 400,000 square yards. One of the Iroquois plants is to be located at Havana and the other at Cienfuegos.

BITUMINOUS SAND-GROUT PAVEMENT.

J. A. BRODIE, city engineer of Liverpool, Eng., has developed a type of pavement which has not yet been constructed in this country, but which is most interesting from the standpoint of a low-first-cost country or interurban road. Mr. Brodie calls his pavement "pitch macadam," but it has been referred to by most engineers who have reported upon it as a "bituminous sand-grout pavement." He has laid forty-one miles of it in Liverpool, and some of his roads have been in service for over fourteen years and are still in good condition.

Col. Wm. D. Sohier, chairman of the Massachusetts Highway Commission, has laid three experimental stretches of road following Mr. Brodie's ideas, although altering his specification somewhat in order better to suit local conditions. About 300 ft. of these experimental roads was laid with asphalt, the remainder being laid with tar. These Massachusetts roads are less than three years old, so that it is a little early to predict their success, but Col. Sohier says that there is no question in his own mind but that the bituminous sand-grout pavement will be stronger and wear longer than any other bituminous penetration or mixed road.

In all, 381 miles, or 44,532 square yards, of this pavement have been laid in Massachusetts. The engineers in charge of the work report that its present condition is excellent, and that there have been practically no repairs. All three sections are on main routes; motor vehicle traffic being probably 90 per cent. of the total, with considerable heavy motor trucking and teaming.

Owing to the success of these roads in Liverpool, there is no doubt but that some enterprising municipality or contractor will experiment with them in Canada in the near future. The following is a résumé of Mr. Brodie's specifications:—

The Brodie Specification.—"Upon a 10-inch hand-pitched foundation, laid and consolidated in accordance with the specification for water-bound macadam, a layer of dry macadam of 2½-inch gauge stones, similar in quality to that used for water-bound macadam, shall be spread evenly to a depth of about 3½ inches (before consolidation). This layer, after being rolled with a light steam roller, shall be grouted with a hot mixture of pitch and creosote oil prepared in accordance with the specification below, and again rolled while hot until the mass is thoroughly consolidated. A second layer of similar macadam of 1½-inch gauge stones 3 inches deep shall then be laid, preferably while the lower layer is still hot. After being rolled dry it shall be grouted in a similar manner with the pitch mixture, and again rolled until the whole is consolidated. The surface shall be finished off with a sprinkling of dry granite chippings. The road shall be laid to an approximately circular camber, with a cross-fall from crown to channel of 1 in 48.

"The pitch mixture used for grouting shall consist of coal tar pitch and creosote oil supplied to the specifications given below, and boiled together in a tank in the proportions of approximately 70 gallons of oil to one ton of pitch, a temperature of from 250° to 300° F. being attained. The proper consistency shall be obtained by applying the following rough tests, *viz.*:—

"A small sample of the mixture when cooled in water to 60° F. shall stretch at least 3 feet without breaking, the threads pulling out very fine. It shall also, when doubled into length of about one foot, bear hitting hard on a hard surface without showing any signs of cracking.

"After leaving the boiler and immediately before being put on the road, an equal quantity of fine shore sand heated to 400° F. shall be added to the pitch mixture, which shall then be kept continually stirred until spread.

"The macadam shall be of durable granite or trap rock from the quarries of North Wales or from other approved quarries having a similar class of rock. It shall be carefully broken into cubical form so as to be capable of passing through the specified gauge in any direction. It shall be cleanly riddled to free it from dust and all flat slatey fragments shall be picked out before shipment.

"2½-inch macadam shall pass through a 2½-inch ring and be held by a 2-inch ring.

"1½-inch macadam shall pass through a 1½-inch ring and be held by a 1-inch ring.

"The pitch shall yield no matter volatile below 270° C. when subjected to dry distillation, and its total volatile organic matter shall not fall below 30 per cent.

"It shall not contain more than 80 per cent. of its weight of matter insoluble in petroleum spirit of 0.700 specific gravity (boiling) and must be free from extraneous matter, such as sand and grit.

"It must twist fairly after immersion for two minutes in water at 60° C. but not under 550° C. (Hereinafter referred to as Clause 3.)

"The oil supplied shall be obtained exclusively by the distillation of coal tar, and shall not contain any portion of the distillate obtained below 240° C. None of it shall re-distil below 240° C.

"The oil as obtained by distillation of coal tar shall not be treated in any way, either by the addition of any coal tar product, or by the extraction of any of its constituents, excepting such extraction as may be necessary to comply with clause 3. It shall contain no moisture. It shall contain no solid matter at 15° and shall have a specific gravity of not less than 1.075 (taking water as 1.00 at 15° C.).

"It shall contain not less than 40 per cent. of its constituents that do not distil over below 320° C. and the 60 per cent. which does distil over below 320° C. shall contain 10 per cent. of tar acids, to be extracted by soda of specific gravity 1.125 (water 1.00)."

The Massachusetts Type.—The three Massachusetts bituminous sand-grout pavements have been constructed by A. W. Dean, chief engineer, and F. C. Pillsbury, division engineer of the Massachusetts Highway Commission, Boston, Mass. The Tyngsboro Road was laid in May, 1914; the Wayland and Natick roads in August, 1914.

The ordinary methods of heating and drying the sand were found satisfactory; the heaters, in fact, being home-made. Some of them were old corrugated metal culverts, 1½ ft. in diameter and about 12 ft. long; others were old iron smoke stacks, about 18 ins. diameter and of varying lengths; still others were old boiler plates. Three or four of these heaters were used simultaneously, being laid parallel to each other. They were moved from time to time in order to have the hot sand near to the point of distribution, so that it could be moved in wheelbarrows from the heaters.

A small shallow trough was used for mixing the sand and tar. This trough was about 4 ft. long, 3 ft. wide and 1½ ft. deep. It has vertical ends, but otherwise was curved like half of a circular cylinder. In other words, it was approximately the shape of half of a barrel that had been split longitudinally. The sand used was very fine and clean, the fineness being required to provide for the suspension in the tar when pouring. The tar was brought to the road in tank wagons, fitted with steam coils. A steam road roller moved the tank wagons during distribution, and also provided steam for heating the coils.

The mixing trough, on a truck with small wheels, was attached immediately behind the tank wagon, and so close that the hot tar could flow from the tank wagon into the trough. The hot sand was brought up from the roadside and measured into the trough, and two laborers on each side mixed the tar and sand in approximately equal proportions, with the aid of pieces of hose. In the rear of the trough was a pipe outlet and a valve through which the mixed tar and sand were let into pouring pots. The usual flat-nozzled pouring pot was used.

Great care was taken in pouring, it being done immediately after mixing, and longitudinally with the road. It was found better to have only one man to do the actual pouring all the time, the pouring pots being carried to him from the mixing trough. This man acquired great skill in pouring and obtained uniform results in the quantity applied.

The broken stone was not less than 1½ ins. and up to about 2½ ins. to 3 ins., effort being made to secure stone as uniform as possible. The thickness after rolling was from 2 ins. to 3 ins., as desired. Before pouring, the stone was rolled sufficiently to prevent it from being rutted by wagon wheels. A fairly safe rule for the quantity of mixture was found to be, one gallon of mixture per inch of thickness in stone. Immediately after pouring, a thin covering of peastone was spread, sufficient in quantity to permit rolling without the roller sticking to the tar. After a thorough rolling, the surplus peastone was swept off, and an application of tar spread uniformly, preferably from a pressure distributor, and at the rate of about half a gallon per square yard. This, in turn, was covered with peastone or chips and thoroughly rolled.

The base, or bottom course of stone, was well drained, and before the top course was spread it was rolled thoroughly, and bound with stone screenings, fine screened gravel or sand. This was not only to preserve its shape during future operations, but also to prevent the escape of the tar-sand down into the bottom course.

A portion of the 300-ft. section that was laid with asphalt, was laid with material of about 140 penetration, the remainder being laid with asphalt of about 45 penetration. It was decided that the penetration should probably be about 100, although the stiffness of the asphalt might be increased according to the weight of traffic. This would also depend somewhat upon the type of asphalt used. The temperature to which the asphalt should be heated would vary according to the stiffness of the asphalt, but in any case should not be so high that it would be much hotter than the sand, as otherwise the mixture would likely foam. It was found that 300° F. was usually about the proper heat.

The Massachusetts engineers state that the cost of the bituminous sand-grout pavement should not be more than ten cents per square yard greater than the cost of the usual penetration type of road. The Massachusetts work, where costs were kept, was not over eight cents in excess of penetration work, and one job ran as low as six cents additional.

SHIPBUILDING ACTIVITY IN DENMARK.

The Copenhagen Floating Dock and Shipbuilding Company has secured a site of 70,000 sq. m. for extending the works; for this purpose the capital is being increased by 1,000,000 kronen, to 3,000,000 kronen. (1 krone = 27c.)

ROAD MATERIAL SURVEYS.

MEMOIR 85 of the Department of Mines, Ottawa, entitled "Road Material Surveys in 1914," by L. Reinecke, has just been published. The volume contains 244 pages, a considerable portion of which is consumed in compilation of general matter. These include the cost of various quarrying operations, transportation facilities from important rock deposits to sections where road metal is required, and local costs of various types of roads. The author's desire in furnishing this information is that it may be helpful to communities improving their road systems.

The preliminary discussion of various types of roads is somewhat elementary and may in sections merit friendly criticism. In the main, however, the data is good and furnishes valuable basic information.

The object of the surveys which have since been and are now being further extended, is to acquire a greater knowledge of our resources of good rock for road metal, thus rendering available more accurate data to assist highway departments in solving the difficult problem of supplying good roads of the highest economic quality at minimum cost.

The territorial surveys recorded are limited sections of the north shore of Lake Huron and adjacent islands, Essex County, Kent County and the north shore of Lake Ontario between Port Hope and Hamilton.

Previous geological surveys showed that large areas of diabase rock existed along the north shore of Lake Huron. In fact, for some years past quarries have been operated in this section. A large amount of rock is crushed, the greater portion of which is exported. The rock has been known to the trade as "trap." This term is somewhat general. According to this report, it includes the "fine-grained, dark, volcanic rocks, the andesites, augite andesites, basalts and other more basic black volcanic rocks, and the porphyritic equivalents of these rocks, including diabase."

The Lake Huron diabase deposits were found to be of high quality. Samples taken from various sections generally showed a toughness of 18 or over. Those taken from the quarry at Bruce Mines ran as high as 27. The "per cent. of wear" test ran from 2 to 4.37. The major portion of samples stood close to 2.5. The rock showed from 40 to 100 in cementing value. Such tests would indicate, as past experience has also proven, that much of this rock is suitable to withstand "heavy traffic" as this term is applied to macadam roads. It is also of excellent quality to be used in asphaltic concrete pavements.

The extensiveness of the deposits permits production on a large scale at relatively low cost. It must be understood, of course, that the very qualities of this rock which make it so valuable for road work cause it to be difficult and expensive to quarry and crush. Veins of epidote and quartz, moreover, render drilling slow, and large fragments of rock constantly fail to shatter until additional small shots are used. The quarrying expenses will, accordingly, always prove high as compared with those of the softer and poorer types of rock.

The location of this material is somewhat distant from central Ontario. However, deep channels facilitate cheap water transportation to the various lower Ontario points of discharge.

Essex County contains little road material of high quality. Gravel deposits, however, are abundantly distributed throughout various sections and are of no mean economic importance in the development of better roads. Field stone, moreover, could be made to yield considerable material. In addition there are supplies of gravel in adjacent territory and also limestone deposits on Pelee Island.

In Kent County, again, the gravels, many of which are of good cementing quality, form the bulk of the local road material.

A territory of 130 miles in length and from one to seven miles in width was investigated along the north shore of Lake Ontario from Port Hope westward. The gravel deposits proved extensive. They carried a uniform average of 70 per cent. limestone, 20 to 30 per cent. hard pebbles, and 0 to 10 per cent. soft pebbles. The cementing value of this material is high. Local roads constructed of these gravels unprotected by a bituminous

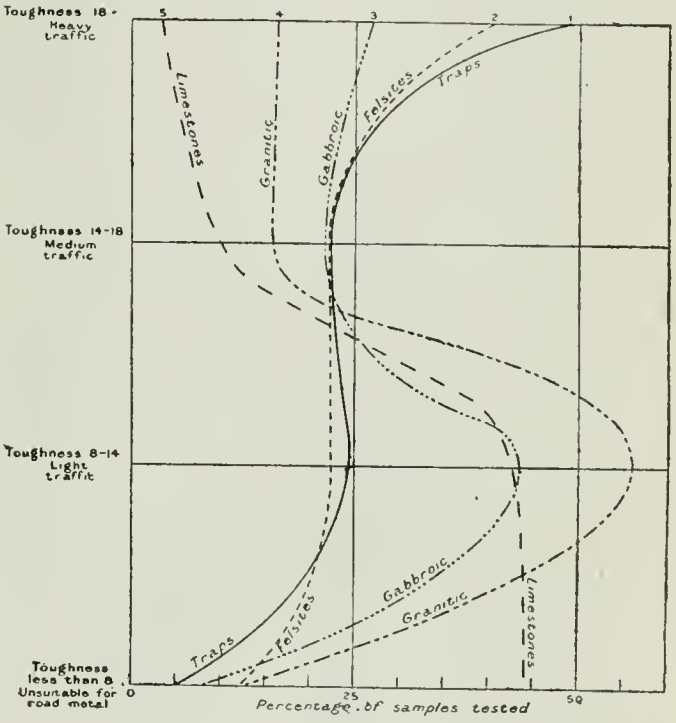


Fig. 1.

Curves showing the relative toughness of various groups of rocks and their consequent behavior under traffic (based upon tests made in the laboratory of the Office of Public Roads, U.S. Department of Agriculture, Washington, D.C.).

Rock grouping used in the diagrams.

1. Traps, including the finer-grained, dark-colored igneous rocks; andesite, augite andesite, basalt, diabase, basaltic and andesitic tuff, breccia, etc.
2. Felsites, including the finer-grained, light-colored igneous rocks; rhyolite, quartz-porphyry, trachyte, etc.
3. Gabbroic rocks, including the coarser-grained, dark-colored igneous rocks: diorite, augite-diorite, anorthosite, gabbro, peridotite, pyroxenite, etc.
4. Granitic rocks, including the coarser-grained, light-colored igneous rocks, granite, syenite, monzonite, granodiorite, quartz-diorite, etc.
5. Limestones, including all varieties of limestone and dolomite.

covering stand up under medium traffic from 2 to 3 years. They do not prove satisfactory, however, with simply

water consolidation when the traffic is fairly heavy. When Portland cement is to be used as a binder, it is found advisable in many cases to screen and mix, as the aggregate varies greatly even in limited sections.

Large boulders of glacial origin are found on the terrace between the old Lake Iroquois beach line and the present shores of Lake Ontario. These deposits are not in close enough proximity to existing and projected roads to be of great economic value at the present time.

The outside sources of supply represent excellent factors as a solution in building projected roads. The trap deposit on the north shore of Lake Huron and at Havelock, as well as the limestone largely quarried at Hagersville, Dundas and other adjacent sections, and the granite at Gananoque, merit consideration in this connection. The limestone deposits referred to are well-known. Those at Hagersville contain from 10 to 25 per cent. chert which, Mr. Reinecke believes, improves the quality of the road material.

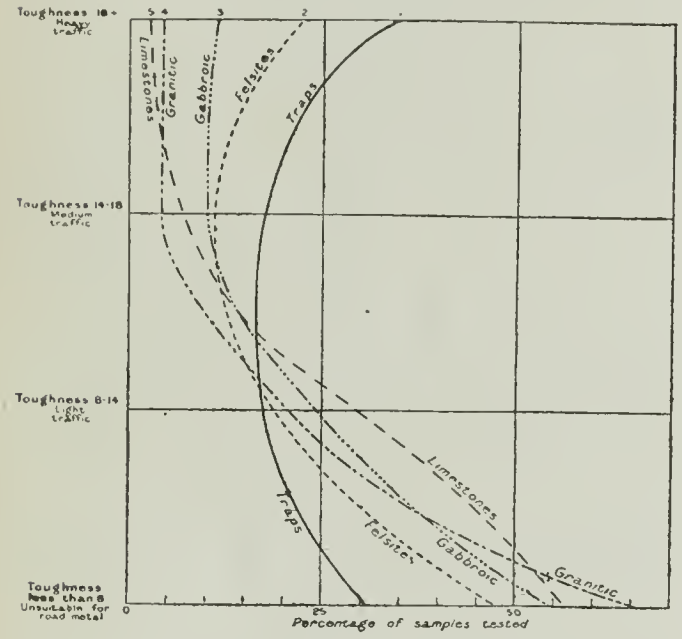


Fig. 2.

Curves showing the relative toughness and consequent behavior under traffic of such rocks as have a cementing value high enough to permit of their use on macadam roads (based upon tests made in the laboratory of the Office of Public Roads, U.S. Department of Agriculture, Washington, D.C.

The accompanying diagrams, together with their respective interpretations, will prove interesting. It is readily seen that trap as a whole furnishes the best road metal. In general, the remaining order of merit is as follows: Felsites, gabbroic, granite, and limestone.

From a careful study of curves such as these, the important part which the quality of metal plays in the success with which a road will withstand traffic can be readily seen. It further serves to illustrate a very important truth, namely, that in selecting the most economical type of road to withstand a given amount of traffic a cheap type such as water-bound macadam should not always be overlooked. While this type of road may fail and consequently prove unsatisfactory if constructed with limestone or granite, were it built with good felsite or trap, its merits might be unquestioned. If the yearly charges against a water-bound macadam road, to provide adequate maintenance and interest and sinking fund charges, do not exceed the combined amount of these charges against a more expensive road, the water-bound macadam should be selected, assuming that it will give as efficient service while in use as will the more expensive road.

It is encouraging to know that our government is doing its share in furnishing data to aid materially in the scientific solution of road problems.

ENGINEERS WILL OFFER SERVICES.

Wills Maclachlan, secretary of the Canadian Electrical Association, was in Ottawa recently, and in conversation with F. T. C. O'Hara, Deputy Minister of Trade and Commerce, Mr. Maclachlan said that engineers who could not enlist are desirous of doing something to aid the government in prosecuting the war. Mr. O'Hara intimated that the government does not understand clearly just how engineers might like to help, and he suggested to Mr. Maclachlan that the engineers should get together and present some definite plan of action to the government.

Upon his return home, Wills Maclachlan wrote to the executives and officials of various engineering societies centred at Toronto and invited them to meet at the Engineers' Club last Tuesday evening. The following gentlemen accepted the invitation: Chester B. Hamilton, R. B. Wolsey, W. A. Bucke, B. G. Buchanan, W. H. Thom, Ernest V. Pannell, R. K. Shepard, Childes C. Clark, S. L. B. Lines, Walter Carr, T. W. Gibson, J. F. Neild, L. N. Arkley, S. B. Chadsey, J. C. Armer, A. H. Hull, W. E. Segsworth, E. P. Mathewson, E. M. Ashworth, E. J. T. Brandon, Alfred Burton and Wills Maclachlan.

The above gentlemen belong to one or another of various societies, including the American Society of Mechanical Engineers, the Engineers' Club of Toronto, the Society of Chemical Industry, the Toronto Section of the American Institute of Electrical Engineers, the Toronto Chapter of the Ontario Association of Architects, the Institute of Electrical Engineers of England, the Canadian Mining Institute and the Canadian Society of Civil Engineers. While they were not officially representing any of the above societies at the meeting last Thursday evening, it is thought that they will no doubt be able to interest officially the various societies to which they belong, and to secure their co-operation in the movement if they can evolve any practical plans for assistance by engineers other than enlisting or volunteering for munition work under the direction of the National Service Board.

Discussion at the meeting last Thursday evening brought out a wide range of suggestions and a committee was appointed to consider them. Canadian engineers and scientists are invited by Wills Maclachlan to send him any suggestions they would like to make, regarding ways in which engineers can be of use at home in furthering the war.

SHIPBUILDING IN SWEDEN.

The Finnboda yard, near Stockholm, has decided to construct a new slip, capable of accommodating vessels 375 ft. long and of 5,000 to 6,000 tons. The necessary blasting operations will be commenced shortly, and the work is expected to be so expedited that the first keel can be laid in the summer of 1917. The first boat to be built will, it is stated, be only 250 ft. long.

Editorial

REPORTS FROM MUNICIPAL ENGINEERS.

Many municipal engineers will during the next few weeks be busy preparing their reports of work done during the year which has just closed. It is to be hoped that the practice of preparing written reports whenever possible will be more general in the future than has been the case in the past. There has been a tendency on the part of too many municipal engineers to evade written reports.

The value to one municipality of how work is progressing in others, what methods are being employed to advantage is obvious. To the municipal engineer falls the duty of supplying his corporation with exact and complete data, in order that such data may be of use not only to himself and the community which he serves at the time, but also to other municipalities.

It is, however, to himself that the preparation and presentation of such reports will be most valuable. Access to such records as these will have a direct bearing on his future success, if only for the purpose of having an exact record of all his reports of progress, proposals, opinions, etc., as furnished to works committees and council, so that when an emergency arises it will be possible for him to make immediate and exact repetitions of statements made perhaps months before. In this way the engineer who has fortified himself against the freaks of memory will find in it a safeguard to his professional standing.

The municipal engineer of to-day is called upon to express opinions upon so many different phases of civil engineering work that it is incumbent upon him, perhaps more than any other class, to take this exhortation (not to trust too much to memory but make written reports) especially to heart.

The municipal engineer must have a very diversified knowledge of engineering. He is called upon to deal with problems in which a knowledge of hydraulics, sanitation, surveying, railways, roads and pavements, etc., etc., are called for, all of which makes it important not to be hampered by a failure of memory.

Finally, a report emanating from a municipal engineer should be complete in itself, making oral explanations unnecessary.

IRON AND STEEL INDUSTRY DURING 1916.

The growth of Canada's iron and steel industry has of late years been phenomenal. While in 1914 the industry was at a low ebb, it is gratifying to note that to-day Canada ranks eighth among the steel-producing countries of the world.

In the report on the production of iron and steel during 1916, just made by Mr. John McLeish, B.A.F.S.S., who is in charge of the division of mineral resources and statistics, the following highly interesting facts are given covering the activity in this field of effort during 1916:—

The records received from the producers show that the production of pig iron and of steel ingots and castings during the first eleven months of the year which together with estimates for December show a probable production of pig iron in Canada during the twelve months ending December 31, 1916, of 1,171,727 short tons (1,046,185 gross tons) and a probable production of steel ingots and direct steel castings of 1,454,124 short tons (1,298,325 gross tons), of which 1,423,485 short tons were steel ingots and 30,639 short tons were direct castings.

The production in 1916 during the first six months and monthly during the last six months was as follows, in gross tons:—

	Pig iron, gross tons.	Steel ingots, gross tons.	Direct castings, gross tons.	Total, gross tons.
Six months ending June ...	501,872	577,999	11,715	589,714
July	82,154	101,178	2,284	103,462
August	78,450	108,889	2,299	111,188
September ...	91,736	116,828	2,524	119,352
October	101,436	126,577	2,924	129,601
*November ..	95,237	119,468	2,745	122,213
†December ...	95,300	119,930	2,865	122,795
Six months ending December	544,313	692,970	15,641	708,611
Twelve months ending Dec..	1,046,185	1,270,969	27,356	1,298,325

*Partly estimated. †Estimated.

The production of pig iron in 1915 was 913,775 short tons and of steel ingots and castings 1,020,896 short tons, showing, as noted above, an increase in the production of pig iron in 1916 of about 28 per cent. and an increase in production of steel ingots and castings of over 42 per cent.

The 1916 production was greater than that of any previous year, the second largest production of pig iron having been 1,128,967 short tons in 1913 and of steel ingots and castings 1,168,993 short tons also in 1913.

Of the total production of steel ingots and castings in 1916, about 43,790 short tons (39,098 gross tons) were made in electric furnaces. In 1915 only 61 short tons were reported as having been made in electric furnaces.

BITUMINOUS SAND-GROUT PAVEMENT.

Under the above head an article appears on page 17 of this issue, descriptive of bituminous sand-grout pavements laid in Liverpool, Eng., and near Boston, Mass.

While the Boston roads are purely experimental and are not old enough to be particularly significant, it is understood that some of the Liverpool roads have been down as long as fourteen years, and are still in good condition. So far as *The Canadian Engineer* is aware, no roads of this type have been built in Canada, but the success of these roads in England will undoubtedly lead to their trial in this country.

The suggestion is made, therefore, that it would be of distinct interest to highway engineers and road contractors in Canada, if the Canadian & International Good Roads Congress, which is to meet this winter in Winnipeg, could induce Mr. J. A. Brodie, city engineer of Liverpool, to attend the convention and deliver a thorough paper upon this subject. Mr. Brodie is generally admitted to be one of the leading road authorities in England, and his visit to Canada at this time would be most opportune in view of the large number of roads that will be built after the war is over.

The city engineers throughout Canada would warmly welcome a visit from Mr. Brodie, and the members of the Canadian Society of Civil Engineers would, no doubt, co-operate in his entertainment.

PERSONAL

H. McEWEN, superintendent of the Prince Edward Island Railway, Charlottetown, P.E.I., has retired after 42 years' service.

E. W. DELANO, formerly of the engineering department, Bangor & Aroostook Railway, has been appointed division engineer, Lake Superior District, C.N.R., with office at Capreol, Ont.

H G. BARBER, formerly resident engineer, Canadian Pacific Railway, Nelson, B.C., is now a lieutenant in the 239th Battalion Overseas Railway Construction Corps, Canadian Expeditionary Force.

A. C. BEDFORD has been elected president of the Standard Oil Company of New Jersey, to succeed the late John D. Archbold. Mr. Bedford has for some years been vice-president and treasurer of the company.

JOHN G. SULLIVAN, M.Can.Soc.C.E., chief engineer of the western lines of the Canadian Pacific Railway, has been announced a nominee for president of the American Railway Engineering Association for the coming year.

G. H. TRIPPLEHORN has resigned his position with the Chatham Cement Tile Company, with which he has been associated for a number of years, and has gone to Detroit, where he will assume the management of a cement company.

H. G. SCHANCHE, who has been with the Laurentide Company, Limited, Montreal, and is now finishing his forestry work at Pennsylvania State College, has been elected an associate member of the Canadian Society of Forest Engineers.

J. R. W. AMBROSE, M.Can.Soc.C.E., chief engineer of Toronto Terminals Railway Co., Toronto, has been named as one of the ten candidates from which the nominating committee of the American Railway Engineering Association is to be selected.

J. A. MacDONELL, formerly head of the contracting firm of MacDonell, Gzowski & Company, Vancouver, who went overseas with the First Canadian Pioneers, has been promoted to the command of that corps. He has also been recommended for the D.S.O.

R. COLCLOUGH, formerly superintendent, District 1, International Division, Canadian Government Railways, Levis, Que., has been appointed superintendent of District 1, Transcontinental Division, Quebec, Que., succeeding J. E. Morazain, transferred.

Lieut. K. L. DUGGAN, of the Mounted Rifles, son of Mr. G. H. Duggan, of Montreal, president of the Canadian Society of Civil Engineers, has been reported wounded in action. Mr. Duggan's other son, Lieut. H. S. Duggan, was killed in action last spring.

W. H. FORTIER, of the Dominion Glazed Cement Pipe Company, and Sanitary Engineer DALZELL, of Vancouver, will, at the request of the Vancouver Board of Works, make tests regarding the relative merits of cement pipe and vitrified pipe, and submit a report.

W. A. COWAN, A.M.Can.Soc.C.E., formerly division engineer, Transcontinental Division (Ontario), Canadian Government Railways, has been appointed acting general superintendent, Transcontinental Division, Cochrane, Ont., during the absence of F. P. Brady, on account of ill-health.

Dr. H. N. WHITFORD and ROLAND D. CRAIG, having completed their report to the Commission of Conservation, Ottawa, concerning the area of merchantable timber in British Columbia, have now left that province, the former to take up a position in the Forest School, Yale University, and the latter having gone to Ottawa.

F. A. CHISHOLM, A.M.Can.Soc.C.E., formerly superintendent of the St. John's, P.Q., division of the Southern Canada Power Company, has been appointed superintendent of power of the Sherbrooke Railway and Power Company, vice J. T. Kemp, resigned. A. P. BROADHEAD, superintendent of the Drummondville division of the Southern Canada Power Company, succeeds Mr. Chisholm at St. John's, while H. P. FISK takes the place of Mr. Broadhead at Drummondville.

J. H. CUNNINGHAM, of Ladysmith, Vancouver Island, B.C., who only recently returned from a visit to Nova Scotia, has resigned as manager of the Extension colliery of the Canadian Collieries (Dunsmuir), Limited, and has been appointed superintendent of the coal mines of the Nova Scotia Steel and Coal Co. He left Ladysmith for the east early in December. He has been succeeded at Extension by T. A. Spruston, who has been manager of the same company's No. 7 mine, Comox colliery, VI.

CLYDE LEAVITT, of the Forestry Branch, Ottawa, will attend an international forestry conference in Washington, January 18th and 19th, at which special efforts will be made to obtain national and international co-operation in a campaign to check the spread of the white pine blister disease. The conference has been convened by P. S. Ridsdale, secretary of the American Forestry Association, Washington.

CANADIAN SOCIETY OF CIVIL ENGINEERS, CALGARY BRANCH.

One of the most interesting and instructive war addresses delivered in Calgary was given Tuesday evening, December 26th, at a smoker held by the Calgary Branch of the Canadian Society of Civil Engineers. The speaker was Capt. H. Sidenius, headquarters staff officer of military district No. 13. "Military Engineering and Trench Warfare in the European War" was his subject. This he handled capably and illustrated his talk by the use of drawings on a blackboard as he proceeded.

Capt. Sidenius went thoroughly into the technical details of the subject, explaining by means of diagrams and maps the methods of building the various kinds of trenches necessary in the present war. He also described the construction of obstacles and wire entanglements, machine gun emplacements, telephone connections between the front trenches and the several official stations behind the lines, as well as the details of organization of trench defence and attacks. He exhibited maps prepared for air craft observations at Ypres last spring. A feature which illustrates the marvelous efficiency of the military organization at the front was brought out in his explanation that the results of air craft observations made in the forenoon was issued in the afternoon of the same day on completely finished maps showing the exact location of the enemy trenches as well as all other natural or artificial features of the ground.

Capt. Sidenius gave a general explanation of the organization of trench warfare, and at the conclusion was given hearty applause and a vote of thanks by the society. Mr. A. S. Dawson presided.

More than 30 per cent. of the members of the Calgary branch have already gone to the front, and it is the intention of the Society to unveil a roll of honor at an early date.

The Canadian Engineer

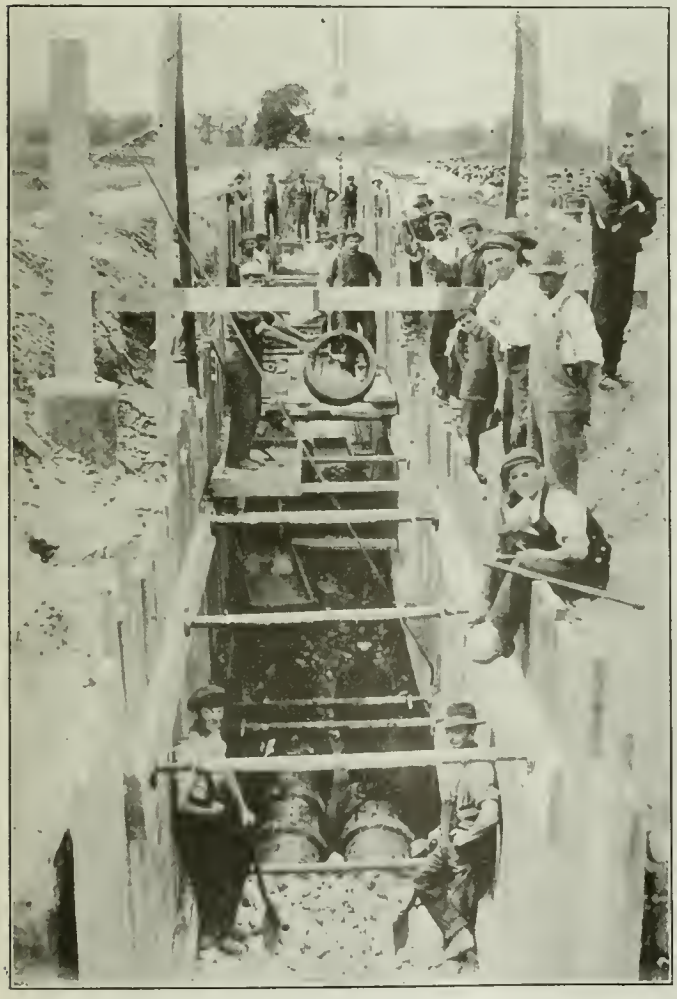
A weekly paper for Canadian civil engineers and contractors

BRANTFORD WATERWORKS

ILLUSTRATED DESCRIPTION OF A TYPICAL ONTARIO WATERWORKS PLANT—DETAILS OF EQUIPMENT.

By R. O. WYNNE-ROBERTS, M.Can.Soc.C.E.

BRANTFORD, Ont., derives its supply of water from an infiltration area of about 170 acres in extent, lying within and near a horse-shoe bend in the Grand River. There are intakes in the river and water is raised therefrom and discharged into the distributing pipes leading to the infiltration area. The city owns about 300 acres of land. The water is collected by two sets of lines. The first consists of two 15-inch perforated earthenware pipes about 1,700 feet long and the



Construction Work on Collection Gallery.

second consists of two 18-inch perforated tile pipes 1,200 feet long. The perforations are one-eighth inch wide and two inches long, and extend two-thirds round the pipes—the solid part being at the invert. The first lines discharge into the old pump well, which is 15 feet in diameter and 23 feet deep, and the second lines are connected to the new pump well, which is 25 feet in diameter and 29 feet deep. The hydraulic canal conveying water to Messrs. Slingby's works, passes the front of the pump-house and is slightly higher than the pump-house floor. This canal is about 100 feet wide and 8 feet deep and is controlled by gates. It is connected to the Grand River about a mile up-stream from the pump-house, where a dam with flashboards has been built across the riverbed to impound water and to increase the head. The city intakes are about a quarter of a mile below the dam.

The pump-house is situated about 2 miles from Market Square and the difference in surface level is about 23 feet. The daily quantity of water pumped varies from about 1,670,000 Imperial gallons in December to about 4,250,000 gallons in March. The average daily consumption is about 2,610,000 gallons, and as the population is

Pumping Station.

about 26,000 the average quantity per head is 100 gallons per day.

The pumping plant consists of: One Holly double-expansion, Corliss gear, steam-driven pump, 18-inch and 36-inch cylinders, installed in 1900. The suction is 24 inches in diameter and the delivery 20 inches. This pump with steam at 85 lbs. per square inch is rated to deliver 5,000,000 gallons per day under 80 pounds station domestic water pressure. One Worthington 1,670,000-gallon-per-day direct acting double expansion steam pump, installed in 1889, and one Gaskill 1,670,000-gallon-per-day double expansion steam-driven pump 12-inch and 24-inch cylinders, 12-inch suction and 16-inch delivery, installed

in 1889. These pumps draw water from the old pump well which is situated under the pump-house floor, and are ordinarily used as emergency pumps.

There is also a new installation of pumps in an extension of the pump-house. These consist of two De Laval domestic supply pumps and two De Laval booster pumps for fire purposes. The two domestic supply pumps are three-stage centrifugals operated by synchronous motors. These pumps are rated to deliver 3,360 gallons per minute under a head of 200 feet when running at 750 r.p.m. The motors are Canadian Westinghouse 250-h.p. at 4,000 volts, 25 cycles, 3 phase, 29 amp., 750 r.p.m. The direct current exciters are 6-kw., 125 volts, 48 amp. These pumps have connections to a 16-inch suction line from the new well and 12-inch deliveries. Each booster pump consists of two De Laval single-stage centrifugals worked in series at 1,250 r.p.m. connected to a De Laval steam turbine by a reduction gear. The domestic supply pump delivers water into an 18-inch header at about 85 lbs. pressure, but in case of fire this connection is shut and the water is passed through an intermediate header to the booster pumps to increase the pressure to about 120 lbs. per square inch, returned to the main header and thence to the city through various connections ranging from 10 inches to 20 inches in diameter. These pumps were supplied by the Turbine Equipment Company, Toronto, and have been in operation for a few months.

View of Engine Room.

The steam is supplied by any two of three John Inglis & Co.'s return tubular boilers, each 16 feet long 72 inches diameter. The fires are banked and the steam pressure is maintained at 100 pounds. The feed-water passes through a 125-h.p. Hoppes feed-water purifier to reduce the temporary hardness of the water.

The De Laval steam turbines are connected to C. H. Wheeler's surface condensers and provided with a Mullan's air pump. The older engines are fitted with jet condensers.

The venturi meter is a M type, 9-inch throat, with an 18-inch inlet and a 20-inch outlet.

The pump-house is heated by Webster's vacuum-steam heating plant.

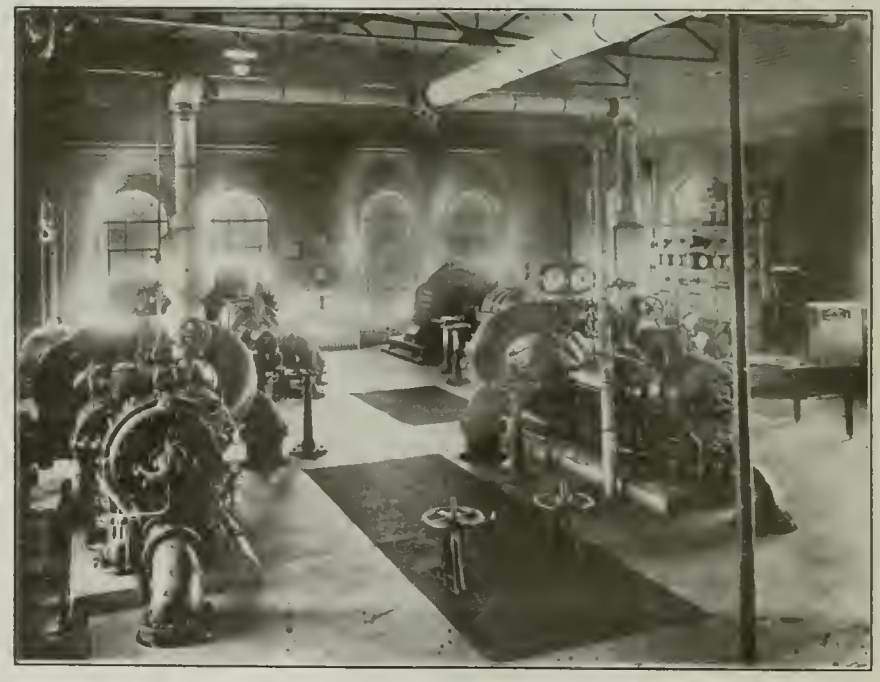
There is an overhead travelling crane with a runway extending the whole length of the pump-house.

A new screen-house, 32 feet by 40 feet is now being built near the river intake where an electrically driven submerged pump will lift the water about 10 feet into the distributing mains to feed the infiltration area. At present the water is raised 25 feet by a temporary pumping outfit and is discharged into the distributing system.

There is a 1,500,000-gallon open trapezoidal reservoir in the lower part of the infiltration area and near the pump-house to receive the excess yield of the infiltration galleries.

A small slow sand filter has been constructed adjoining the canal to treat water taken therefrom. This filter is 20 feet by 40 feet and 9 feet deep with 3 feet of sand. The water, after passing through the filter, is allowed to percolate into the ground to saturate the infiltration area and then recollected by the galleries and conveyed to the pump wells.

During 1915 about 952,800,000 Imperial gallons of water were pumped against a head of about 200 feet. The cost of fuel and energy was $11,538.30, which is equivalent to $12.15 per million gallons and 6.08 cents per million foot-gallons—that is, one million gallons raised one foot high.



Another View of Pumping Equipment.

(Continued on page 28.)

FREEZING OF WATER IN SUBAQUEOUS MAINS LAID IN SALT WATER AND IN MAINS AND SERVICES LAID ON LAND.*

By William Whitlock Brush.

THE transformation of water from the liquid to the solid state, known as ice, as a result of the abstraction of heat from the water, is a process familiar to all, but the exact conditions under which such transformation takes place are not so generally known. This withdrawal of heat may be by means of radiation, conduction or convection, the transfer of heat being accomplished by any one of these agencies operating singly or in combination.

Fresh water increases in density as the temperature is lowered, until a maximum is reached at 39° F. There is then a gradual reduction in density to the temperature of 32°, when the liquid changes to the solid form, known as ice, with a specific gravity of 0.89. It is this transformation that is particularly interesting to waterworks men, and some of the more important features of such transformation will be briefly discussed. The temperature of water is remarkably constant while ice is forming or melting. The temperature of the air may be many degrees below zero, but the temperature of fresh water, even though it be in a rapid running stream, will not be more than 0.01 below 32° F. Again, as long as there is ice in the water the temperature will only be a similarly small fraction of a degree above 32° F., even though the temperature of the air be many degrees above the freezing point. A mixture of ice and water forms the most constant temperature known to physicists.

It is popularly believed that running water may be lowered to a temperature of several degrees F. below the freezing point before ice will be formed. This is an error. Absolutely still water may be cooled to approximately 10° F. below the freezing point without ice forming, but as soon as there is the slightest agitation of the water an immediate formation of ice takes place and continues until the heat released by the change from water to ice warms the remaining portion of the water to the freezing point. The latent heat of water at the freezing point is large, amounting to 80 calories per gram, or sufficient to raise 143 pounds of water 1° F. for every pound of water changed to ice.

Ice is divided into three kinds, based upon the manner in which it forms, *i.e.*, surface ice, frazil ice and anchor ice.

Surface ice is the common form which appears on the surface of the water when the temperature of the water is cooled to the freezing point. It appears first near the shore and gradually extends out as the deeper water is cooled, the entire surface being eventually covered after the temperature of air remains below the freezing point for a sufficient period to cool the entire surface water to just below 32° F. After the ice is formed, the thickness increases, mainly through the conduction of heat from the water through the ice, it being necessary to conduct not alone the heat in the water but also the latent heat previously in the water, which is released as the water changes to ice. As the conductivity of ice is low, being only one thirty-second of that of iron, this process is relatively slow and the thicker the ice sheet the slower the increase in depth of ice.

*Abstract of paper read before the 4 States Section of the American Waterworks Association.

Frazil ice is the form which appears in running water when the temperature of the water falls below 32° F. and where an ice sheet cannot form due to the agitation of the water. It forms at the surface and may be made up of flat plates, if the surface is not greatly agitated, but more frequently is in the form of minute needle crystals which join together and form a bulky mass, floating lower in the water than the ordinary surface ice.

Anchor ice is ice which is found attached or anchored to the bottom of a river or a stream, and results from the cooling of the material at the bottom of the river by radiation, and the resultant freezing of the water which comes in contact with the surfaces, which have been cooled below the freezing point. It will only occur under a clear sky and where there is nothing to interfere with the process of radiation. As dark objects radiate heat more rapidly than light-colored ones, anchor ice will form more rapidly on a dark stone than on a light one. It will not be formed under a bridge where radiation is interfered with, nor under ice, which also prevents radiation. When the sun's rays strike the masses of ice, earth and stone, they are absorbed and frequently the whole mass will become loosened and float to the surface. Large rocks are thus raised and carried down stream with the ice.

These three forms of ice are all of interest to the waterworks engineer, not alone as affecting the problems to be met at the source of supply, when such source may be a reservoir or stream, but also in the distribution of water, as will be shown later.

It is generally considered that ice is a poorer conductor than water. This belief is probably founded upon the very material protection which ice or snow gives against frost penetration. Such protection is mainly due to the resistance of ice and snow to the transmission of the heat waves of radiation. Clear water offers little resistance to the radiation of heat, but is a very poor conductor of heat. Due to the difference in density of water at different temperatures, water will transmit heat through convection, or the movement of the molecules, much more rapidly than will ice, by conduction. The molecules of ice are unable to move freely, and transmission of heat through ice, by convection, is therefore negligible.

Pressure lowers the temperature at which water changes to ice, but its effect is very slight, thus, a pressure of 1 pound per square inch will lower the freezing point 0.009° F. Assuming the normal pressure in a water main to be 40 pounds per square inch, the lowering of the freezing point by such pressure would amount to less than 0.04° F.

The introduction of certain chemicals into the water lowers the freezing point. The most common chemical found is salt, and all are familiar with the lowering of the freezing point caused by the presence of salt. The volume of salt determines the temperature at which the ice forms, the salt being thrown out by the crystallization of the water, so that ice formed in salt water is fresh. The ordinary sea water will freeze at about 27° F. and the temperature of the water is therefore well below the freezing point of fresh water. As the percentage of salt in the water decreases, the freezing point rises, but this freezing point is probably below 30° F. in the tidal waters surrounding our sea-board cities.

Formation of Ice in Water Mains.—The formation of ice in water mains is dependent upon the temperature of the water in the main and the velocity of current, the pressure being of negligible effect, as has previously been shown. It is probable that the water as drawn from a

reservoir or stream is seldom below 33° F., as the formation of ice and the density of the water generally prevent the cooling of the water below this temperature. If the water in passing through the main is not reduced in temperature to below 32° F. there will be no danger of freezing. If it is reduced below 32° F. ice will begin to form, the ice forming a coating on the inside of the pipe, due to the high conductivity of the iron. As the ice film thickens, the transmission of the heat of the water to the surrounding earth and thence to the air is greatly retarded, the conductivity of ice being such a small fraction of the conductivity of the iron. If the velocity in the main is reduced through a lowering of the rate of draft, the water in the main is more readily cooled, and the rate of ice formation correspondingly increases. This ice formation may be properly classified as surface ice It is probable that in a main where the velocity is high, the water is cooled slightly below the freezing point and a form of frazil ice created. Such ice might eventually clog the main, stopping the flow, and the whole mass of water in the main quickly change to solid ice. In the report of the committee of the New England Waterworks Association on the depth at which mains should be laid to prevent freezing, submitted in 1909, reference is made to slush ice forming in a main laid in a salt marsh at New Brunswick, New Jersey. The velocity in this main was high and frazil ice probably formed. A stoppage in flow may also occur after a thaw, due to the loosening of the film of ice which has formed during the cold spell, and which may break up and flow through the water until it reaches a point in the main where the ice may not have broken loose and where the floating ice will become packed in such a manner as to completely stop the flow. While this might account for the stoppage of flow in mains, especially in house services, after a thaw, which is an experience not uncommon to waterworks superintendents, there is a record of an actual reduction in temperature of soil below 32° F. following a thaw, and such reduction would be ample reason for the freezing up of water mains coincident with a thaw.

Prevention of Formation of Ice in Subaqueous Mains.—Where a main is laid in salt water it is common practice to lay the main without any earth cover. The iron is therefore exposed directly to the salt water, which is usually in motion, and heat may be rapidly abstracted from the water in the main through the three agencies of transmission, *i.e.*, radiation, conduction and convection. Radiation is active in clear water and especially so from the black pipe. The iron is also an excellent medium for conduction, with the heat being absorbed from the surface of the iron by the water flowing over the pipe. Convection will readily do its part within the pipe. The temperature of the salt water, during a period of severe cold, may be lowered several degrees below the freezing point and under such conditions ice will form in the water main and the main will be completely clogged, unless the rate of flow is sufficient to maintain the temperature at the discharge end of the main, at or above 32° F. If a main is laid in a body of fresh water, there is little danger of freezing, except at the point where the main enters the water, as the temperature of the water will be above 32° F. and a covering of surface ice will prevent excessive radiation. If the main is laid in the bottom of a rapidly flowing fresh water stream, it is possible that through radiation and the cooling of the water in the stream, ice might form in the main, but it is improbable that such ice would be of sufficient thickness to interfere with the delivery of water through such main.

Frost Penetration on Land.—The committee of the New England Waterworks Association, which reported in 1909 on freezing of water mains, stated in their report that they had received 90 replies from 320 circulars sent out to waterworks engineers and superintendents, 53 communities had had trouble with freezing of mains, 50 per cent. of the freezing had occurred at dead ends, and in all cases there had been little or no velocity. In all but three cases the mains were smaller than 10 inches in diameter, and only seven as large as 8 inches in diameter. In every case the ground was frozen below the axis of the pipe. Forty per cent. of pipe was laid in clay, 48.6 per cent. in gravel, 5.7 per cent. in sand and 5.7 per cent. in rock. The depth of penetration of frost was found to be 1 foot greater in the streets than in the fields, and 1 foot 5 inches deeper in gravel than in clay, the depth in sand being about midway between the depth in clay and in gravel. The ice was found at times in concentric rings in pipe as large as 24 inches in diameter, and no stoppage of the pipe had occurred. The ice formation was not always solid, but sometimes in the form of slush. The depth of frost penetration varied materially. The committee called attention to a belief or tradition that existed in the minds of many plumbers and water works superintendents, that most stoppages occurred during a thaw, following a period of severe cold weather, it being suggested that this might be caused by evaporation from the surface during the early stages of the thaw, producing additional refrigeration or reduction of temperature at the depth of a water main sufficient to cause freezing. The committee comment that the reports received did not support this theory. In the discussion of the report an instance was cited where a pipe was laid in the late fall in rock cut, and the backfilling was composed of frozen earth and rock, giving a very porous filling. A comparatively slight current was maintained in the pipe. In the early spring, on a day when it was warm enough so that it was comfortable to be about in shirt sleeves, the pipe stopped up. It was left until the following morning, when it was found that the pipe was again clear.

Mr. Jesse O. Shipman, division engineer, public service commission, New York City, states that, where services are run through bays in the subway, where, in general, the distance from the surface of the ground to the service is about 4 feet, with 6 inches of earth below the service and 12 inches of concrete forming the roof of the subway, trouble from the service clogging with ice usually occurs a day or so after a thaw, following a severe cold spell, has set in.

The writer endeavored to find records of ground temperature but was able to locate only those of Profs. H. L. Callendar and C. H. McLeod, of McGill University, Montreal, Canada, and recorded in the proceedings of the Royal Society of Canada for the years 1895, 1896 and 1897.

These experiments were started in 1894 by Professor Callendar and he was later assisted by Professor McLeod. The location selected for the experiment was level ground in a garden where there was turf and loose light-brown sand to a depth of 8 feet 6 inches. Below this sand was stiff blue clay to a depth of 30 feet from the surface. Water was found in the sand for some distance above the clay but the sand was nearly dry to a depth of 5 feet.

A trench 3 feet wide and 9 feet deep was dug, with one face vertical. Into this face horizontal holes were bored for nearly 3 feet, using a one-half inch rod. Electrical resistance thermometers, consisting of a carefully insulated coil of platinum wire about 3 inches long and protected by an external tube of glass or copper, were inserted in these holes and connected to the indicating

apparatus by insulated leads of convenient length. The holes were bored at depths of 1, 4, 10, 20, 40, 66 and 108 inches. In the earlier periods readings were taken daily at 12 noon, but later a continuous recording apparatus was installed. An abstract of the snow conditions and temperature recorded are given herewith.

This record shows very clearly the material effect of snow on the depth of frost penetration and the slight cover probably required when snow is always present early in the winter. The record of the thermometer buried at a depth of 10 inches, which showed in April, 1895, a drop of 0.2 to 0.3° below 32°, which was the temperature at the beginning of the thaw, is very interesting. This shows that a lowering of the ground temperature below 32° F. may results from a thaw. The following notes are copied from the text:—

Winter 1894-1895.

Depth of thermometer.	Period temperature was below 32° F.	Minimum temperature.	Snow conditions.
Air	Dec. 20 to March 20	—10° F. in Feb.	10 inches snow Dec. 28 which increased to 21 inches by Feb. 1, 33 inches by Feb. 7. Began to melt in March. Final melting of snow between April 7 and 14.
1 inch	Nov. 25 to April 14	27° F. in Dec., just before snow fall	
4 inches	Nov. 28 to April 14	28° F. in Dec., just before snow fall	
10 inches	Dec. 16 to April 14	31½° F. in Dec., just before snow fall	
20 inches	0	33° F. Dec. 14, melting snow	
40 inches	0	35½° F. April 20, melting snow	
66 inches	0	38° F. April 21, melting snow	
108 inches	0	41½° F. April 22, melting snow.	

Winter 1895-1896.

Depth of thermometer.	Period temperature was below 32° F.	Minimum temperature.	Snow conditions.
Air	Nov. 20 till Apr. 10 except for short rises	—15° F. Feb. 18	Practically no snow till Jan. 24. The winter is remarkable for lateness of heavy snow fall and for the rapidity of its disappearance.
		27° F. Jan. 22, before snow fell	
1 inch	Dec. 2 to April 20	28° F. Jan. 22, before snow fell	
4 inches	Slightly shorter period than for 1 in.	30° F. Jan. 22, before snow fell	
		32½° F. Jan. 23	
10 inches	Dec. 22 to April 20	34¼° F. April 15, melting snow	Light snow fell in Nov. and Dec., disappeared. Heavy snow fall commenced Jan. 24 and increased to maximum of about 30 inches in March. Snow disappeared about April 12.
20 inches	0	38° F. April 20, melting snow	
40 inches	0	41° F. April 25, melting snow	
66 inches	0		
108 inches	0		

The final thawing of the ground took place at a depth of 10 inches on April 19th. The 10-inch thermometer which had remained within less than 0.1° F. for about two months previously, showed a depression of 0.3 when the thaw reached it, probably due to lowering melting point by dissolved salts. . . . . The percolation of water caused a slight simultaneous fall in the two thermometers next below.

Winter 1896-1897.

Depth of thermometer.	Period temperature was below 32° F.	Minimum temperature.	Snow conditions.
Air	Nov. 15 to March 20	Mean temperature air Dec. 23, 5° F.	No snow during early part winter; frost penetrated much deeper into soil than during two years previous; thawing of ground after disappearance of snow was lengthy operation; 20 days were required. Temperature at 20 inches did not rise above freezing till May 1.
1 inch	Nov. 23 to April 3	10° F. Jan. 20	
4 inches	Dec. 1 to April 10	12° F. Jan. 20	
10 inches	Dec. 15 to April 18	19° F. Jan. 20	
20 inches	Jan. 5 to April 25	27° F. Jan. 20	
40 inches	Nearly reaches 32° F. during Mar. and April.	33° F. March and April.	
66 inches	0	36° F. April 22, melting snow	First fall of snow quite light Dec. 5. Practically no snow till Jan. 20. About 20 inches snow on ground from Jan. 20 to Feb. 20. About Feb. 20 snow increased gradually and uniformly to about 28 inches by March 1. Snow disappears about Apr. 2 or 3.
108 inches	0	39° F. May 2, melting snow.	

This record obtained in a carefully conducted experiment is confirmation of the possibility of a thaw causing the freezing of water pipes. The rapid lowering of ground temperature by cold water percolating through the ground was strikingly shown several times during the period covered by the records. While percolating waters may lower the temperature, the presence of moisture reduces the likelihood of services freezing, for the following reasons:—

(*a*) The freezing of the water releases latent heat which is transmitted to the ground.

(*b*) The frozen ground is a poor conductor of heat.

(*c*) Water is a poor conductor of heat, and when it is held in the ground by the action of capillarity, it cannot readily conduct heat by convection, as it would if it were free to move.

Prevention of Formation of Ice in Mains and Services.—Where frost penetration has extended to, and possibly beyond, the level at which a water main or service has been installed, the water in the main or service will freeze unless the temperature of the water in such main is kept at or above 32° F. This can only be accomplished by having such quantity of water pass through the main that the rate of abstraction of heat will not be sufficiently rapid to cause the temperaure of the water to fall below 32°

As has been pointed out, in the supply from the Croton River, the temperature of the water, even during a very cold spell, is found to be about 34°. As long as there is sufficient water passing through the mains to prevent this temperature being reduced by more than 2°, *i.e.*, to 32° F., there will be no danger of freezing of water in the mains. By testing the temperature of the water as it is drawn from a hydrant, it can be determined whether there is or is not likelihood of the main freezing. No rule can be formulated which would answer the question as to whether a main will freeze under given conditions. A protecting covering is certainly a great aid in reducing the danger of freezing, and snow on the ground is an almost sure preventive.

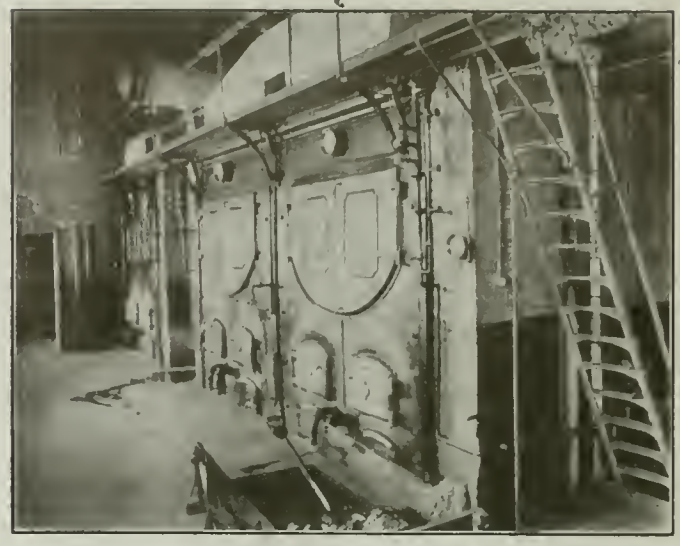
Thawing Ice in Mains and Services.—The problem of thawing out frozen mains and services has been greatly simplified through the utilization of the electric current at low tension. While it was found that this method was not of much value when applied to a main laid in water, where the heat generated through the passage of the electric current would be rapidly dissipated by the flowing current of water, the condition where the pipe is covered with soil is entirely different and much more favorable to the thawing of the main. As the electric current passes through the metal, the heat generated will thaw both the ice which is formed within the main and the ice which is formed in the soil outside of the main. The transmission of this heat to the surrounding earth and thence to the surface is very slow and a comparatively small amount of current is required to make the necessary change from ice to water. It is not necessary to describe the actual application of electricity to the mains as this has been set forth in detail many times.

The writer found in his investigation of this subject that a study of the formation of ice in streams has greatly aided him in obtaining a clearer conception of the conditions under which ice is liable to be formed in mains, and on this subject he has drawn freely from the "Treatise on Ice Formation," by Howard T. Barnes, Associate Professor of Physics, McGill University, Montreal, who has made extensive experiments and observations on ice formation in the St. Lawrence River and elsewhere.

BRANTFORD WATERWORKS.

(Continued from page 24.)

The water commissioners for 1916 are: Mr. John Fair, C.E., chairman; Mr. A. G. Montgomery, Mr. J. W. Rowlby, K.C. (Mayor), Mr. Fred. W. Frank, secretary; Mr. Thomas Lamb, superintendent; Mr. David L. Webster, chief engineer.



Boiler Room, Brantford Waterworks.

BRITISH FIRM OUTBIDS UNITED STATES FIRMS.

There was great surprise a few days ago when it was announced by Secretary Daniels of the United States Navy that Hadfields, Limited, of Sheffield, England, was the lowest bidder on contracts for 16-inch and 14-inch armour-piercing naval projectiles. Not only were their bids $146 lower per shell on the 14-inch shells and $237 lower on the larger ones than the lowest American bids, but they offered to deliver the order in eleven months and sixteen months respectively, while the best the American firms could do was 22 and 24 months. Hadfields became a serious competitor for naval contracts in 1912, when they underbid the American firms on 14-inch shells by a considerable margin.

Commenting on the wide disparity between the English bid and the American proffers, Secretary of the Navy Daniels said he thought it singular that American firms with their tremendous facilities were unable to compete either as to price or time of delivery with the English manufacturer.

The report of the German steel syndicate regarding shipments of steel for the fiscal year 1915-1916 states that of the total shipments 87 per cent. were for home consumption, as against 81 per cent. the preceding year. The total steel production of Germany for the same period is given as 14,700,000 tons, as compared with 11,700,000 tons the preceding year.

Dutch shipyards have been informed by the German authorities that they will be put on the German black list if they repair Norwegian vessels, whether the work is carried out with German material or not. For Danish and Swedish vessels special permission has to be obtained. In the case of vessels being built in Holland of German materials, permission for export has to be obtained, and no such permission will be available for vessels built for Norwegian account.

THE ENGINEERING SOCIETY—ITS PAST, PRESENT AND FUTURE ACTIVITIES.*

By Ernest McCullough.

A LITTLE over a century ago the men engaged in works of civil construction organized a society and called it a society of civil engineers. The right to assume the title of engineer was contested by the only men to that time recognized as engineers, that is, the men engaged in military engineering work, and it became necessary to define a civil engineer when the society finally applied for a royal charter. The result was the incorporation in 1828 of the Royal Institution of Civil Engineers of Great Britain, civil engineering in the charter being defined as "the art of directing the great sources of power in Nature for the use and convenience of man."

For a number of years in the first half of the last century it was common to read on title-pages of books the term "Mechanical Civil Engineer," "Mining Civil Engineer," etc., the inference being that in those days all men not military engineers were civil enginers. The development in the manufacture of power brought about by improvements in the steam engine and the vast increase in railway building finally resulted in the distinct professions of Mechanical Engineering and Mining Engineering, and later Electrical Engineering. Now the civil engineer is said in a late report of a committee of the Institution of Civil Engineers to have almost disappeared in the original meaning of the term. The men known as civil engineers are engaged in many special lines of work, so the multiplicity of specialties and the multiplying number of special societies is something requiring notice. Before the civil engineer was known as such there were road builders, bridge builders, canal builders, colliery viewers (engineers), surveyors and builders. The fundamental education in all branches being the same, the development of industry has had the effect of recreating the old sub-divisions, more highly trained perhaps, but conditions now are as they were before the engineer evolved as an entity.

The time has come when the engineering society should pause and consider if it is doing necessary work. The earlier societies performed a valued service. They brought together men having similar interests; where the older men read papers and discussed papers which were intended purely for instructional purposes, most of the engineers being trained by apprenticeship. There existed few schools and there was a demand for trained men. Young men picked up their knowledge as best they might in the offices of eminent practitioners, and at the society meetings met other men of experience. Thus they obtained the broad view of their business so necessary for future success. The educational value of the meetings was so great that a professional spirit developed and was fostered.

The technical, or engineering societies, have not developed with the work of the engineer. They still consider themselves as institutions organized solely for educational purposes. This is the way they are conducted, but the majority of the members know many societies exist rather as an evidence of the standing of the members than for their declared purposes. The modern technical journal is doing more real educational work than any society, no matter how large or how important it may be. The pages of the weekly and monthly papers bring to us news from the front fresh, and in a way which the more formal papers of a society cannot. Our society proceedings are become encyclopedias, which are consulted less frequently than are the pages of the journals maintained purely for profit.

Some societies are beginning to realize that something is lacking in the old methods, and this is shown by the growth of social activities. That there is a real demand for this side of the training of a technical man is proven by the societies which feature the social side.

May it not be asked if the central idea of the original technical societies was not the young man? Granting that he was the reason for the inception of such societies, we can ask ourselves if we have been for some time treating him fairly. Are we now taking proper notice of him and the increased difficulties attendant upon his endeavors to secure a foothold in his chosen work with the increase of competition following upon the great development of the engineering school and the popularity of technical training to-day?

The young man feels he has not been paid the proper attention. There is a well-founded idea that engineering societies have for many years past been mutual admiration societies of successful men, and used for furthering of insidious advertising by men qualified to take full advantage of the position their membership brings them. The discussions at the meetings are too frequently inadequate, and real criticism is seldom developed when the author of the paper is of commanding eminence. Some men even use the society to which they belong for exploiting patented processes and materials.

The third method, namely, the affording of patent and legal advice, needs to be approached with care. The society should have an attorney who can help members who have trouble in collecting pay,—that is, members who fall into the hands of unscrupulous employers. There are many such. There was organized a couple of years ago a society of authors to protect individuals against the rapacity of certain dishonest publishers. It is said to have been very successful. Medical men have such means for collecting bad accounts and to protect them against blackmail, for a number of physicians and surgeons are annually attacked by former patients who know a man will often pay large sums rather than get undesirable notoriety. This side of the medical societies is so well taken care of that few accounts of such attacks ever get into the public press. It is understood that lawyers and ministers of the gospel have similar legal protectors, and some of us believe our colleagues, the architects, have a few societies in which the business side of the profession is properly cared for. Engineers should similarly protect themselves against attacks on character and attempted extortion or robbery. Just what the new association intends to do in the matter of patent advice I do not know, and supposedly the members have only a vague idea, but that there is some good reason for including this item we cannot doubt.

The fourth method is concerned with legislation for the technical man. The people of the United States have gone mad on the subject of legislation. They apparently wish to preserve the individuality so long a characteristic of Americans, combined with the socialistic condition which is the inevitable result of the passing of a large number of regulatory laws. It is not for us to object and stand too much on dignity. We must recognize the fact that a condition and not an hypothesis confronts us. The legal profession would not have the standing it enjoys were it not for the very thorough way in which the lawyer

*Journal of the Western Society of Engineers.

has intrenched himself legally. The medical profession did not enjoy the high standing it now has until legally it was protected from the men who otherwise would bring the profession into disrepute. The architects are working hard to obtain legislation to make architecture a closed profession, beginning with the passage of the license law for architects in Illinois in 1897. Now many of the States have similar laws, the greater number of which were passed the present year. Engineers, myself among the number, were opposed to legislation to license engineers, but conditions in the State of Illinois became so intolerable on account of the monopoly given to architects that we obtained this year the passage of a law to license structural engineers.

We attempted to have the lien law amended to protect engineers, for at the present time they are not protected. Architects are so protected, their society seeing to this item some years ago. The fight, however, for the license law was so strenuous that the lien law was not fought for hard enough, but we hope it will be looked after in the next session of the legislature. The next piece of legislation to be attended to is one fixing the status of sanitary engineers or the plumbers will get ahead and obtain control of the design and construction of sanitary work. A bill in the interests of the plumbers was prepared to be presented to the legislature at the session just closed which would have given plumbers a practical control of matters properly belonging to sanitary engineers. Not for the purpose of making a closed profession of sanitary engineering, but to prevent injustice to such engineers because of legislation which may be secured by men in other lines of work it will no doubt be necessary to have examinations and licenses for them.

However, a better way will be to secure a law requiring the registration of professional engineers with an examining board qualified to examine men in different specialties so that the word "engineer" will possess a dignity comparable with the titles of the other learned and honorable professions, which stand high in the esteem of the public. Not only must the modern engineering society see that legislation is secured to protect and elevate the engineering profession, but it must also carefully look after proposed legislation to the end that no laws will get on the statute books which work harm to the people of the state. That is, as citizens, we must protect fellow-citizens whose lack of knowledge of technical affairs leaves them at the mercy of special interests.

The fifth method is proper publicity. What is it? Proper publicity depends upon changing ideas and advances in civilization. That is, methods of publicity in one generation which are perfectly proper may be improper in a succeeding generation. The advertising methods of the live, wideawake business man may be considered coarse and unbecoming for the professional man. They are usually so considered. Is this idea a survival of a generation past? Is it, as many young men claim, a fetish worshipped by professional men for the purpose of helping older men maintain their pre-eminence and hold the young man back The question must be answered individually just now, for the engineer, no matter how decently he may conduct his business, is frequently partly a professional man and partly a business man. When he is employed in a confidential manner and given a fee he is a professional man. When he is on a regular payroll he is a technical employee. When he assumes the direction of work he may be said to be a business man. Throughout his life the technically educated man, the engineer, is at times a professional man, a technical employee and a business man. He must do some publicity work, and societies should not be hidebound in what is to be considered proper means of publicity to be employed by individual members. It should be enough for the societies if the members remain decent and bring no discredit on the work of the technical men.

The societies heretofore have concerned themselves with the publicity work of individuals. What is now a crying need is publicity work of a proper sort by the societies for the benefit of the membership, and, incidentally, of the technically educated men not members of any societies. Through proper publicity work all technical men not members will want to become members. Incidentally, the work of technical men will be so placed before the public that there will be an increase of good material in the ranks. Proper publicity should have the effect of sifting out desirable men from those not so desirable. It is due to improper publicity work that we have complaints to-day that there are too many unfit men now enrolled as engineers. These men, no matter how unsuited they may be to the work of the engineer, have a place somewhere in this world where they can fit in, and it should be a part of the duty of the engineering society of the future to find the hole into which these misshapen pegs may fit.

WINNIPEG AQUEDUCT CONTRACT PROTESTED.

Ten contracting firms who unsuccessfully tendered upon the construction of nine and a half miles of reinforced concrete pipe for the Greater Winnipeg Water District, threatened to obtain an injunction restraining the Board from letting the formal contract to the Winnipeg Aqueduct Construction Co., and as a result the Board have agreed not to let the contract before investigating the whole matter. The contractors allege that the engineer called for tenders upon his own specifications, permitting each contractor, however, to tender upon alternative designs. Only two contractors tendered upon their own alternative designs and the contract was awarded to the Winnipeg Aqueduct Construction Co. upon a "lock-joint" design. This company is said to have tendered jointly with the Canadian Lock Joint Pipe Co., of Regina, Sask.

Some of the other contractors allege that they had been told by the chief engineer of the water board not to figure on a lock-joint pipe, but it is stated that the conversation was misunderstood. In explaining to the Board his preference for the lock-joint tender, the chief engineer is reported as having stated that the lock-joint pipe is preferable to any other and also cheaper than the specifications that he had originated. His only reason for not having specified lock-joint pipe in his own specifications was that there would not have been any competition, as the manufacturers of the lock-joint pipe hold all the patents on this type of construction. His own design, while inferior, brought in the element of competition.

The Winnipeg Aqueduct Construction Co. were not the lowest tenderers on the engineer's design.

The complaints are to be put in writing and all the tenderers are invited to be present at the next regular meeting of the Board. The Tom Sharpe Construction Co., one of the unsuccessful tenderers, allege that they were furnished with inaccurate specifications, and that their tender cannot be rightly compared with other tenders on account of their having been furnished with incomplete plans.

FUNDAMENTAL CONSIDERATIONS IN THE MAKING OF PLATS.*

The general principles to be followed in developing a proper street plan have been laid down by Professor Unwin as follows:—

Having settled the purpose of the different areas, determined the general character of growth and the approximate direction desirable for main and subsidiary highways, the town planner finds himself with the following component parts out of which to make his design, namely: The main centre-point, or climax, dominating the whole; the secondary centres in definite proportion and relation to it; and the main highways linking them up; the whole giving the bones or main framework of the design.

Within the space defined by this framework, having special relation to the secondary centres and proportion to the primary highways, we have the network of secondary highways; while within the areas which these leave, for the purpose almost solely of giving access to the buildings we have the minor roadways or drives, which should be in relation to any subsidiary centre-point, and both in relation and proportion to the framework of secondary highways. No system cuts up the land into more awkward corners or more thoroughly destroys the street facades than that which consists of a framework of diagonal highways laid upon a rigid gridiron system of minor roads, and from no system do such unsatisfactory road junctions result. In town planning it is essential to avoid being carried away by the mere pattern of lines on paper. Order, definiteness of design there must be, but there must first be grasped an understanding of the points where order is important and will tell, and of those where it matters little.

These principles may perhaps be restated as follows: In every city there is a central business area to and from which the greatest amount of traffic flows. There are, in addition to this central area, subsidiary centres of activity, either business, social, educational or residence. Each of these subsidiary centres should be connected by direct routes having easy gradients with the central portion of the city. It is not necessary, in fact it is not even desirable, that these routes should be straight, but they should be conditioned by the topography and by existing improvements. The subsidiary centres should also have direct means of communication with each other. After these main lines of travel have been laid down, secondary lines may be developed also in conformity with topographical and other conditions. This will leave, then, certain areas of larger or smaller extent to be subdivided into tracts by means of purely local streets. Now it is not at all important—in fact, it is extremely undesirable—that these local streets should all follow the main points of the compass. The systematic division of our country into townships and sections has been a great convenience in many respects, but it is carrying the influence of the section line entirely too far to make it—as has been done so universally throughout the western state—the basis of all street planning work. Each tract of land into which the primary and secondary system of streets divides should be platted solely with a view to its own special requirements, with such orientation of blocks and arrangement of streets as will serve to develop to the best advantages its own individual peculiarities. It is by no means important that these local streets should be continuous, in fact it add very much to the beauty and detract nothing from the utility of the district if these streets are not continuous, but are so arranged as to furnish desirable building sites, closing the vista at convenient points. By following this plan the sharply angular lots involved in the diagonal street laid across the rectangular street plan will be very largely avoided. Each tract will have a character and an attractiveness of its own and the city will be free from the curse of dull uniformity.

The platting of any district should, of course, be varied to meet the topographical conditions. In some cases, for instance, we have steep hillsides. The folly of platting such hillsides in the regulation way into blocks consisting of two tiers of lots separated by an alley or sometimes by no alley at all, is apparent. In grading the streets laid out in this manner there will necessarily be heavy cuts on one side and heavy fills on the other. The cost of grading is therefore enhanced, as is also the cost of adjusting the property to private use. In such cases it is very much better if narrower and more frequent streets should be platted, so adjusted as to give reasonably good gradients and easy access to the property; these streets to be separated by a single tier of lots. These lots might be a little longer than the ordinary lot. The property then has the advantage of permitting all of the residences to be so situated that they have an outlook away from the hill instead of having half of them face into the hill. Furthermore, they will have access both from the rear and in front, which is a great convenience under these conditions. Where the ground is more uniform the ordinary plan of platting may be followed, but even here the exercise of a little ingenuity will yield very desirable results. It is not at all necessary that even on flat lands all blocks and lots should have uniform dimensions. This was the case in New York City, the lots all being 20 to 25 by 100 ft., and if you wish to build a church or a factory, a house or an office building, you have no choice as to dimensions except to take as many lots as may give the needed frontage.

Authority, therefore, should be vested in the city to regulate not only the size and location of streets dedicated to public use, but the size of the lots themselves. We are all familiar with the fact that the farther the lots are situated from the centre of the city and the cheaper the land the smaller the lot becomes. Public interest and convenience require that there should be public control over this feature of platting.

Then, too, it has sometimes been the custom when plats fail to receive the approval of city authorities that the owner proceeds to sell the lots off by metes and bounds descriptions, without regard to the public interest. The law should provide a certain subdivision of a section or a minimum size and prohibit the sale of smaller tracts unless a proper plat had previously been duly prepared and filed for record. In the making of any plat it must be borne in mind constantly that the present use of the property may—undoubtedly will in many instances—be greatly modified as time goes on. In so far as possible such future use should be anticipated and the plat adapted to such changing use as nearly as may be. This changing use of property, due, of course, to the fact that a city is a living, growing organism and not a dead piece of mechanism, constitutes one of the chief difficulties of city planning. The erection of garden cities, with every detail ordered before hand, seeks to eliminate this difficulty by fixing the maximum limits of the future city. It is better from this point of view to build a new city than to permit the old one to grow beyond its boundaries.

It is important that alleys should be required in all blocks platted on reasonably level ground. Such alleys will have a use even when the property is used solely for residence purposes, in that they permit the construction of garages in the rear of the property. Later on, as the

*Abstracted from a paper by Arthur H. Dimock, presented at the 7th Annual Convention of the League of Washington Municipalities.

use of the property becomes more intensive and as it becomes occupied by large buildings, these alleys become more and more useful for the service of such buildings, relieving the street from the more objectionable and unsightly necessities of such service, such as for instance, the collection of garbage.

In all modern street planning, we must necessarily take into consideration the immense change in traffic conditions which is taking place. The motor bus is rapidly replacing the street car. The number of passengers carried by street cars in London in 1914 showed practically no increase over those carried in 1911. For the same period, however, passengers carried by motor buses showed an increase of about 60 per cent. It is true, of course, that London is not so adaquately supplied with street cars as some American cities. However, the great convenience and flexibility of motor bus transportation will inevitably increase its use in our cities regardless of the facilities afforded by street car systems. The effect of this development upon the street system should be carefully considered by municipal engineers. When this traffic is properly controlled by the municipality—and it is as much the function of the municipality to supply adequate means of transportation as it is to provide an abundant supply of water or electric energy—it may be that the tendency to congestion of travel on certain streets will be reduced because it will be possible to occupy more streets with lines of bus transportation than it was possible to occupy with street cars. This will have a tendency to scatter this traffic and to utilize more fully the street system. On the other hand the great increase of motor-driven vehicles has led to an enormous increase in street traffic. The streets in any city which a few years ago were suburban in their character now carry heavy traffic. There are some thoroughfares towards which, on account of their location, traffic tends to flow in vast quantity. The planning of streets so to care for this increasing traffic will probably call for increasing widths, not only of the main thoroughfares but of many secondary streets as well. The Royal Commission on London Traffic recommended that the principal arterial highways be 140 ft. in width and that the streets be graded down to a minimum of 40 ft. In my judgment, no street should be less than 60 ft. in width except where situated on steep sidehills or where it will manifestly have nothing more than purely local use. The question as to the width of a street opens up, of course, an interesting and essential feature in city platting.

It is now recognized that the greatest municipal mistake of the 19th century was the failure to control the development of suburban areas. One of the marked features of the last century was the tremendous growth of cities—a growth fostered and made possible by modern developments and methods of transportation and intercommunication. There is little doubt that this remarkable growth will continue for many years to come. The modern city is beginning to lose its squalor and unattractiveness and is becoming the most healthy and most desirable spot on earth in which to live. For this and many other reasons, the continued rapid growth of cities is assured. The development of cities, however, will not be confined to the great centres of population. All cities at all favorably situated will continue to grow. It is important, therefore, that not only our larger cities, but that the smaller communities shall embrace every opportunity to lay our systematically and with foresight as may be possible the territory which they will some day occupy. All of our cities and towns will from time to time extend their boundaries and add new territory. This territory will usually be already platted and its future fixed. Too often this platting will have been done without reference to the needs of the future city and without any consultation whatever with the city authorities. Now, in order to secure the proper development of this suburban territory —that is to say, of areas outside the present official boundaries of our towns and cities—it is essential that the control of the platting and laying out thereof be vested in some authority in which the city would have, if not the paramount, at least an equal, voice. In providing for this control of the development of suburban areas, it will frequently happen that other municipalities are included in the district tributary to some growing city. It will be necessary, of course, to consider the rights and privileges of such municipalities. We should not, however, lose sight for one moment of the fact that the public interest and convenience of the whole community and not of any part thereof should be the controlling factor in these decisions. The law might require, for instance, that cities should have the power to create a zone outside of the existing boundaries, in which zone they should have a voice in the development and platting of the streets. All plats within this zone prior to approval by the legislative body vested with this authority should bear the approval of a commission composed of the county engineer, the city engineer and possibly a state officer, say, for instance, the professor of municipal engineering at the state university. Or the law might provide that plats within such district or zone should not become effective until approved by some state officer, as for instance the State Commissioner of Public Lands. Or possibly this approval by a state official might not be required except in cases of inability to agree between the county and city authorities. Another method would be the creation of town planning commissions with power to lay out all such lands and to require all plats to conform thereto. These suggestions are purely tentative, but I am sure that the problem is one of great importance to all of our cities, both great and small.

Another power which the city should have is that of compulsory replatting. In many of our cities areas were platted many years ago when the country was covered with thick timber or sage-brush and no one except a few prophetic souls realized that it would one day be covered with a dense population. These plats were often laid out entirely on paper in accordance with the controlling section lines. No regard was paid to hills or valleys or any other features of topography. They were laid out in many instances by real estate promoters interested solely in securing the greatest possible number of lots per acre. The real estate promoter of the type so familiar to our western cities has been the curse of modern city development.

It is reported that a four years' programme of harbor development is being undertaken at Aomori, Japan, including two detached breakwaters, two moles and a quay. The works are estimated to cost about $775,000.

According to statistics published by the Spanish Consejo de Minera 439,835 tons of pig-iron and 387,314 tons of manufactured forms of iron and steel were produced in Spain in 1915, as against 382,044 and about 330,000 tons respectively in the previous year.

During the last fiscal year San Francisco has constructed more pavement under public assessment than during any other like period of the city's history. The total area paved was 472,253 sq. yds. The average costs for various types were as follows:—Asphalt, $1.91; bituminous rock, $2.14; basalt rock, $3.42; vitrified brick, $3.35.

EXPORTATION OF ELECTRICITY—AN INTERNATIONAL PROBLEM

RELATION OF A POSSIBLE COAL EMBARGO BY UNITED STATES TO A CURTAILMENT OR STOPPAGE OF CANADA'S ELECTRIC POWER—AN INSTRUCTIVE STATEMENT OF AN IMPORTANT MATTER.

By ARTHUR V. WHITE.
Consulting Engineer, Commission of Conservation of Canada.

THE people of Canada, and especially of Ontario, should understand and fully realize the extent to which they are dependent upon others for their coal supply, and understand also their increasingly great dependence upon hydro-electric power as well as its relationship to coal.

Both the United States and Canada, as well as many of the European countries, are now experiencing a shortage of coal supply with consequent increases in price. The present, therefore, is an opportune time to review the Niagara power situation. In the course of this survey we shall consider a number of statements† made by various authorities.

In November, 1916, the District Attorney in charge of the investigation held at Buffalo respecting the coal situation, asked one of the witnesses:—

> "If the Canadians put an embargo on power when there is a power shortage, should we not put an embargo on their getting coal when there is a shortage here?"

In 1891, Mr. E. B. Borron, in making his report to the Ontario government on the lakes and rivers, water and water powers of the Province of Ontario, drew special attention to the fact that Ontario has no true coal. Mr. Borron stated:—

> "Thus it will be seen that in respect of fuel and consequently of steam power, Ontario occupies on this continent a very unfavorable, one might say, unenviable, position, as compared with the maritime provinces and British Columbia, and with many, if not most, parts of the United States, and still worse as compared with England, Belgium and other great manufacturing countries in Europe."

That the time may come when the United States may deem it expedient to reserve her supply of coal for her own use, is not impossible. Dr. George Otis Smith, Director of the United States Geological Survey, commenting upon the world's supply of coal, and with particular reference to the reserves in his own country, states:—

> "This glance at the world's reserves of coal shows plainly not only that the United States leads all other countries in production, our annual output being nearly 40 per cent. of the total, but also that it possesses the greatest reserves. Yet in respect to no mineral is there greater need to emphasize the folly of exporting the raw material. Let us keep our coal at home, and with it manufacture whatever the world needs."

Dr. Smith advises: "Let us keep our coal at home and with it manufacture whatever the world needs." Is it without significance that such a policy should even be suggested?

Examples are not wanting to show that when countries have recognized the fact that certain of their natural resources were essential to their national welfare, policies have been adopted designed to stop or curtail the exportation of such natural commodities.

Consider, for example, the phosphate rocks so valuable as agricultural fertilizer. A few years ago when the United States government perceived that they would require the products of their own phosphate beds, the phosphate lands of the west were formally withdrawn from private entry, thus retaining these deposits of fundamental importance to the future of the nation, as its property. Commenting upon the phosphate situation, President Van Hise, of the University of Wisconsin, stated:—

> "Indeed, by the statesmen of foreign civilized nations, exportation of phosphates would be regarded as unthinkable folly."

and, to use his own words, he urged for the United States:

> "that there should be a law which prohibits absolutely the exportation of a single pound of phosphate rock."

However, it is not necessary to go outside of Canada to find advocates of this doctrine. It has been stated time and again that the growing industrial and other needs of Canada require that there no longer be exportation of Canada's electrical energy to the United States, without acceptable *quid pro quo*. This policy of Canada's retaining her electrical energy for her own use, is that which stimulates one like the District Attorney to ask the very pertinent question above quoted:—

> "If the Canadians put an embargo on power when there is a power shortage, *should we not put an embargo on their getting coal* when there is a shortage here?"

As we have just seen from a foregoing quotation, Dr. Smith goes even further and definitely counsels, "*let us keep our coal at home and with it manufacture whatever the world needs.*"

Ontario and Canada may yet require *every unit of electrical energy* just as much as the United States may yet require *every pound of phosphate rock*, or may find it expedient to retain *every pound of coal.*

In an article dealing with the *Exportation of Electricity*,* the writer in 1910, made the following statement, which is equally true to-day: "Certainly the people of Ontario and Canada are in better circumstances to maintain a supply of heat and power if their water powers, including their full share of international water powers, are reserved to themselves and not permitted to be exported, except upon terms and conditions which will conserve absolutely the present and future interests of the citizens of Canada. Not only would the water powers of Canada provide, to a certain extent, a substitute for the coal supply of the United States as a means of furnishing light and heat and power, but control of these water powers would secure a basis upon which negotiations for coal could be conducted in a possible day of need. Canada would be in a position to exchange, if need be, part of her electric energy for part of the coal supply of the United States. It is obvious, however, that if the United States interests should control both the coal and the

†For purposes of emphasis portions of the statements are here printed in special type.

*The Exportation of Electricity. By Arthur V. White, in *The University Magazine*, of October, 1910.

water powers, the situation of Canada would become exceedingly grave."

In the present condition of world affairs no demonstration is needed of the truth of the statement that the keen competition of large commercial interests too frequently constitutes a most serious menace to the peace of nations. There have been times when, on account of commercial rivalry, international relationships have become so strained that exercise of a nation's force of arms has been enlisted on behalf of the demands of large private or corporate interests.

Some years ago when the relations of the United States with Canada were under discussion before the "Select Committee on Relations with Canada, of the United States Senate," Mr. Joseph Nimmo, Jr., addressed the committee with respect to the possibility of Canada dealing with her transportation facilities in such a manner as would adversely affect interests in the United States using Canadian transportation, and stated that:—

> "In the entire range of our Canadian relationship, from Halifax to Vancouver, the United States holds an overpowering advantage over Canada, and at every point. The suspension of the transit trade would be of comparatively small disadvantage to the United States, whereas it would be utterly disastrous to Canada. . . . It is high time for the people of this country to appreciate the fact that their national government holds a preponderance of commercial power on this continent as absolute as the preponderance of its military power, and to demand that those who are charged with the affairs of government shall adopt such measures as shall prevent any interference by a foreign power with the course of the development of our domestic or foreign commerce."

In its official **Opinion** rendered comparatively recently, the Public Service Commission of the State of New York referred to the possibility of Canada taking back electrical energy which had been utilized in building up United States industries, as follows:—

> "We have nothing before us but the suggestion that the Dominion of Canada may, at some future time, forbid this exportation. This commission must assume that international relations affecting so important a subject as the means of continuing great industries which have grown up in reliance upon the use of this imported power, and, as well, the interests of the Canadian producing companies themselves, have become fixed and subject only to such changes as will fully protect the great commercial and industrial interests and rights now served by this power brought from Canada. The time has long since passed when governments proceed ruthlessly from pure national rashness or anger to destroy the settled accepted commercial relations and formally vested rights of persons and corporations."

In connection with the exportation of electricity, Canada certainly does not desire to assist in creating any circumstances which would even tend to invite a possible carrying out of any such policy as is suggested by the language in the **Opinion** delivered by the Public Service Commission of the State of New York, or in the Address, just quoted, as delivered at Washington before the Select Committee of the Senate on Relations with Canada. Such policies are foreign to the aims and aspirations of the peoples both of the United States and of Canada.

From the foregoing statements, it will be perceived that there is an increased demand in the United States for electrical energy. Let us note more specifically how keenly United States interests desire to possess larger quantities of electrical energy for use in the upbuilding of industries and communities.

The following testimony will demonstrate the views thus entertained. Lieutenant-Colonel J. C. Sanford, reporting on January 6th, 1913, upon the subject of Niagara power, to the chief of engineers, United States army, states:—

> "There is no question but that Niagara power will soon be utilized to the fullest extent allowed by governmental restrictions. *If advantage of the power generated in Canada cannot be had on the American side, manufacturers will be attracted to Canada* by this cheap power, and the industries of this country will suffer accordingly. The effect of present restrictions on the importation of power is becoming noticeable. . . . Manufacturers at present contracting for additional Niagara power, must locate, and are locating in Canada. It, therefore, seems advisable to permit immediately the importation of Niagara power to the fullest extent permissible under the law, and, other things being equal, to grant permission for its importation to the company or companies which will make the earliest use of such power."

The former secretary of war, Hon. Henry L. Stimson, before the Committee on Foreign Affairs, recently stated that:—

> "The investigation which has been made by the engineers indicates that Canada, if we do not take it, will use the entire amount that the treaty permits in a very brief time, so that whatever effect any restrictions on importations would have, would not protect the Falls for more than a very brief period, and *it*

Every Member of

The Canadian Society of Civil Engineers

who can possibly spare the time

should attend the

ANNUAL MEETING

at Montreal, Jan. 23, 24, 25

An interesting program has been prepared—many prominent men will be there—and the meeting should be well attended.

would result in giving to Canada, very possibly, a large number of industries which otherwise would be established on this side of the Falls."

When Representative Chas. B. Smith was speaking on behalf of his bill, he submitted, before the Committee on Foreign Affairs, a letter from a leading citizen of Buffalo, in which it is stated:—

"Every restriction on the importation of Canadian power should be at once removed. Electrical power is a *raw material and should be free.*"

The Sub-committee on Niagara Falls Power, appointed by the Committee on Foreign Affairs, in its report on one of the Cline bills, states that it had been urged for its attention:—

"That the Canadian companies were rapidly increasing their sales and would very soon take the full amount of water they were entitled to and the United States ought to get what power it was able to **now.**"

and they add:—

"If the advancement in the development of power on the Canadian side increases for another year or so—and it is not apparent to the committee that it will not—then the *committee concluded that it was proper to take as large an amount as it could get for consumption in the villages, cities, factories and homes along* **our** *border.*"

Representative Chas. B. Smith, of the state ot New York, in conversation, stated to me that he favored no restriction on the importation of electricity, because if it was good for the United States to have this commodity he thought it was advisable to get as much as possible, and permit it to come into the country without any restriction. This view of Mr. Smith was amply reflected in certain bills of his which provide for no restriction.

In the state of New York there is a ready market for additional electric energy. The **Opinion,** delivered on February 12th, 1914, by the Public Service Commission of the State of New York, records that:—

"There is a large shortage of electric power in western New York, with a strong demand for greater supply which is not being met by existing companies. . . . We are using all the power made on the New York side, and all that has been brought from Canada, and *the demand for more power in western New York is insistent and being urged with great force.*"

It is also stated that Niagara Falls power produced in the United States is so far from supplying the needs of portions of the state of New York, that if the importation of power were prohibited it "would plainly amount to a great public calamity."

When the demands in the United States for more electrical energy are such as those set forth by the foregoing quotations, it is not strange that public organizations and other interests have been prompted to urge action on the part of the Federal government of the United States to relieve this situation.

Various organizations, such as the Water Power Investigating Committee of the New York State Legislature, the Hydro-Electric Association of Buffalo and other places, the special committee of the Committee on Foreign Affairs of the United States House of Representatives, the United States War Department and others, have been studying the problem with a view to at least alleviating the present circumstances.

In the United States, the problem at Niagara is recognized as a national one, and of late special emphasis has been given to the fact that no federal policy of "war-preparedness" can successfully be carried out without increasing the producing capacities of plants at Niagara, which plants are either manufacturing munitions of war, or materials and commodities which are essential to the production of war munitions.

In Canada, efforts put forth, by the Hydro-Electric Power Commission of Ontario*, by the Commission of Conservation, Ottawa,* by the Unions of various Municipalities, by Boards of Trade, and other organizations, have resulted in the conservation for Canada of a large amount of electrical energy which doubtless would not otherwise have been utilized. The activities of the Hydro-Electric Power Commission have very materially increased the consumption of Canadian electricity.

It is not possible within the confines of the present article to do more than briefly indicate some of the chief factors which enter into this problem of the exportation of electricity. Before concluding, however, it will be profitable very briefly to explain a few matters respecting which the public at large, including a large portion of the public press, is in comparative ignorance.

With the factors which we are about to mention held in mind—and not otherwise—one will be able, intelligently, to interpret the course of future discussion or legislation respecting **power development** at Niagara.

For many years the supply of Niagara waters for power purposes was regarded by the public as practically inexhaustible. Companies in the United States, however, had obtained power concessions which, if put into operation, would have drained Niagara dry. The United States federal government recognized the danger of this situation.

The International Waterways Commission, consisting of members appointed by the United States and by Canada, had originated in 1902, following a recommendation in "The Rivers and Harbours Act" of the United States. In 1905 this commission was requested to report upon the general conditions obtaining at Niagara Falls, with the request that there be co-operation between both countries to the end that proper and adequate steps be taken to prevent further depletion of the Niagara waters.

This commission conducted its investigation, co-operatively with the United States War Department and subsequently made its report. Certain recommendations with respect to the preservation of Niagara and the amount of water to be diverted on the United States side, were enacted into law by *The Burton Act.* This commission having completed its work, disbanded about a year ago.

The Burton Act of June 29, 1906, was "For the Control and Regulation of the Waters of the Niagara River, for the Preservation of Niagara Falls, and for Other Purposes." It was regarded chiefly as a temporary measure. It limited the diversion of water on the United States side to a rate not exceeding 15,600 cubic feet per second; and under special permits the *importation* of electrical energy from Canada into the United States, could be had to an aggregate amount of 160,000 horse-power The Burton Act continued in force until 1913, when it lapsed by limitation.

Closely following the passage of the *Burton Act*, the government of Canada, on April 27, 1907, passed **an Act to Regulate the Exportation of Electric Power and Certain Liquids and Gases.** "The Fluid Exportation Act," as it is called, among other features, provides for the taking out each year, of a license permitting the *exportation* of electricity to the United States; and for a possible export tax not exceeding $10 per horse-power per year.

Thus the *Burton Act*—a United States measure—regulated the *importation* into the United States, while the Canadian measure, *the Fluid Exportation Act*, regulated the *exportation* from Canada.

*Consult the *Annual Reports* of these Commissions.

The passage of the Burton Act was furthered through the influence of such organizations as the American Civic Association, the American Scenic and Historical Society, the Colonial Dames of America and others, assisted, also, by efforts of Canadians.

The Burton Act recommended the opening of negotiations between the President of the United States and the Government of Great Britain, for the purpose of regulating and controlling the waters of the Niagara River and its tributaries. Negotiations were opened, and in due course, the **Boundary Waters Treaty** was signed at Washington on the 11th of January, 1909, and ratified on May 5th, 1910. The Burton Act and the Treaty, for a time, were coexistent and the Act was effective until its expiration.

This *Boundary Waters Treaty* specifies nothing with respect to the importation or exportation of electricity, but it provides for a diversion of "not exceeding in the aggregate a daily diversion at the rate of 20,000 cubic feet of water per second for the United States" and of 36,000 cubic feet per second for Canada.

Until quite recently the United States War Department, which exercises federal jurisdiction over Niagara power matters, had not issued permits for more than 15,600 cubic feet of water per second, although it has had the right to issue permits up to the treaty quantity of 20,000. A statement was made in December, 1916, that, on account of the great power shortage, the Secretary of War had decided to release, by permit, the unappropriated water up to the 20,000 cubic feet per second.

The province of Ontario has allotted about 30,000 cubic feet of water per second to provide for the full installations of the existing power companies at Niagara. The balance of about 6,000 cubic feet per second, is to be utilized by the proposed Chippawa development, which, it has been stated, is to be made by the municipalities of Ontario through the agency of the Hydro-Electric Power Commission.

At the present time there is installed on the Canadian side a nominal plant capacity of about 425,000 horse-power, and on the United States side about 260,000 horse-power.

In the United States, federal jurisdiction over Niagara, by virtue of its being regarded a navigable stream, is exercised by the War Department. The Secretary of War issues the permits to the different companies utilizing the water, and the Corps of United States Engineers are entrusted with the enforcing of the various regulations.

In Canada, the control of the waters of Niagara for power purposes is under the jurisdiction of the province of Ontario. The exportation of electricity is under the control of the federal government. The Department of the Interior, Ottawa, issues the annual licenses and, through the agency of its Gas and Electricity Inspection Branch, provides certain supervision of the operations of the power companies.

The licenses issued a year ago by the Department, provided for the following export quantities: Electrical Development Company, 35,000 kw.; Ontario Power Company, 45,000 kw.; Canadian Niagara Power Company, 55,000 kw.; a total of 135,000 kilowatts, or approximately 181,000 horse-power. It is probable that these quantities will be materially reduced in the next licenses issued.

The carrying out of the terms of the Boundary Waters Treaty, as well as adjudication upon certain matters of dispute between the two countries arising out of the use of boundary waters, is now vested in the **International Joint Commission,** which tribunal, in many respects, corresponds to the former International Waterways Commission. Its functions and powers, however, as set forth by the Treaty and more fully defined by Rules of Procedure, are broader. Thus, the means of adjusting differences between the two countries are available through the instrumentality of this Joint Commission, and the Boundary Waters Treaty. The Treaty is based upon the **Doctrine of Equal Benefits.** Each country is entitled to receive its full share of the benefits derivable from the use of one-half of the waters which would naturally flow in the Niagara River. If each country receives the share to which it is entitled there can be no just ground for contention or dissatisfaction.

Having, now, knowledge of the various factors already discussed, including the International Waterways Commission, the Burton Act, the Fluid Exportation Act, the Boundary Waters Treaty, the International Joint Commission and of the functions exercised by the Secretary of War, Washington, by the Department of Inland Revenue, Ottawa, and by the Province of Ontario, with its Hydro-Electric Power Commission, and other organizations, one is in a position to give intelligent understanding to events which may arise in connection with this very important subject—the Exportation of Electricity.

SHIPBUILDING ACTIVITY IN SWEDEN.

The Grängesberg-Oxelösund Traffic Company, which controls most of the Swedish iron ore export, has now placed definite orders with the Gothenburg New Shipyard Company for eighteen steamers, of which ten are to be of 7,500 tons and eight of 5,000 tons. The Transatlantic Steamer Company has ordered two cargo boats from the Lindholmen yard, each of 7,900 tons. The same company has also bought the second 3,000-ton boat being built at the same yard for account of the Rex Company. This is the sixth steamer of this type which the Transatlantic Company has secured, the first, the "Boren," having been delivered in April of this year; the last will probably be delivered in less than a year from that date. This makes six boats of 3,150 tons each delivered to the same company within a twelvemonth, which means a record in Swedish shipbuilding.

It is estimated that there are about 350 cities in the United States that are under the control of commissions, while about 20 have adopted the system of control by city manager.

New York's dual system of rapid transit lines includes the most expensive railroad in the world. This is the so-called Centre St. Loop, the cost of which to the city to June 30th, 1915, as figured by Chief Engineer Craven, of the Public Service Commission, was $16,080,964.09. This is at the rate of $10,843,536.13 per mile of subway and $3,050,837.43 per mile of track.

The Public Service Commission for the Second District of New York has settled a problem which has been vexing it and the gas corporations in its jurisdictions for several years by making an order fixing heat units instead of candle-power as the standard of value for coal gas. Hereafter gas must average 585 B.Th.U. per cubic foot instead of 16, 18 or 20 candle-power as heretofore.

Sulphate of aluminum is needed by Argentina for clarifying its water supply. It was formerly imported from Germany, but it is now difficult to obtain anywhere. American firms are quoting $120 to $185 a ton for it, and the estimated needs for 1917 for the country are placed at 8,000 tons. As a result of a protest to the Government by the Argentina Public Health works, a plant to manufacture the compound from native kaolin has been authorized at a cost of $188,000.

THE EFFECT OF SUDDEN ENLARGEMENT UPON THE FLOW OF WATER IN PIPES.*

By T. J. Rodhouse.

THE experiments presented in this paper have been conducted for the purpose of determining the effect of sudden enlargement of section upon the flow of water in pipes. The distribution of velocities in various sections near the expansion has received special investigation. A comparison between the effects of sudden enlargement and of contraction has been made, and the observed loss of head due to expansion has been compared with the theoretical loss.

The Apparatus.—The apparatus used in carrying on these experiments is a part of the equipment used for experimental purposes in the Hydraulic Laboratory of Cornell University.

Pipes.—The investigations herein presented were limited to the two cases of the effect of sudden enlargement from pipes of one inch and one and one-half inches in diameter to one whose diameter is 2.096 inches. The three sizes consisted of straight, smooth, seamless-drawn brass tubing.

The drawing, Fig. 1, shows somewhat in detail the connections and their positions. The pipe-line was horizontal, and the two pipes of different diameters were carefully aligned so that their axes were coincident. The pipes had been carefully calibrated in previous experiments, and were noted to be clean during the investigations herein described.

Water Supply.—The water supply was drawn from a tank in the attic of the building and at an elevation of about 47 feet above the pipe line. The inlet to the supply tank was controlled by a valve regulated by a float and consequently a very uniform head could be obtained for all velocities up to about five feet per second in the two-inch pipe.

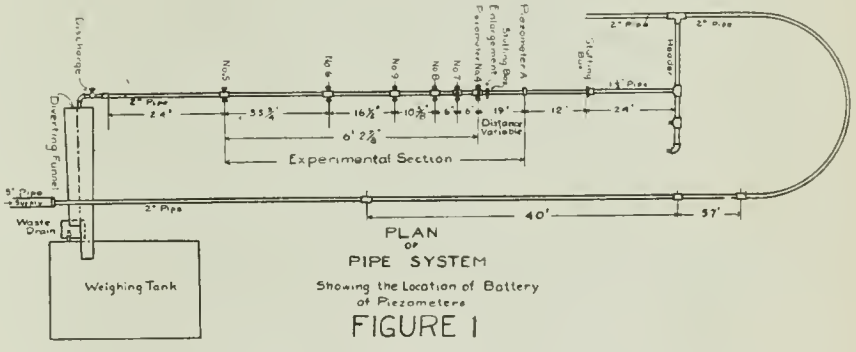


FIGURE 1

Weighing Tanks and Scales.—The discharge from the pipe was through a diverting funnel into a large weighing tank of about 2,500 pounds capacity. The weighing scales were tested and found to be accurate. The error of the scale is less than 1/10 of one per cent., so small as to be neglected without in any way impairing the value of the results.

The Diverting Apparatus.—The diverting funnel leading from the discharge end of the pipe line to the weighing tank was made of galvanized iron with a vertical diaphragm dividing it into two parts, one side leading to a waste drain and the other to the weighing tank. The funnel was suspended by a wire from the ceiling, so as to swing freely, and the time required for thus diverting the jet to or from the weighing tank was less than one-half second. The time periods of weighing were taken with an ordinary watch whose daily variation was only a few seconds from standard time. The duration of a weighing period was from three to five minutes.

The water used was drawn from the regular supply to the University from the new filter plant, was clean and ranged in temperature from 40 degrees Fahr. at the beginning of the experiments, March 1, 1904, to 69 degrees Fahr. at the close, July 15, 1904.

*Abstracted from paper in Cornell Civil Engineer.

Pitot Tubes.—The Pitot tube consisted of a straight, cylindrical German silver tube 1 10 inch diameter and projecting 2 3/32 inches from the end of a larger brass tube of 5/16 inch external diameter by 7/32 inch internal diameter, having hose connections and a setting arm or pointer for indicating accurately the position of the impact opening when placed in the pipe. The tube had only the single impact opening 1 32 inch diameter located 0.04 inch from the end with its axis intersecting at right angles the axis of the tube. The static pressure was taken at the piezometer at the wall of the pipe in the same plane with the tube. The pressures from the impact opening and the static piezometer were conducted to the triple differential gauge through one-fourth inch heavy cotton-insertion rubber tubing.

Guiding Frame.—An attachment invented by Prof. G. S. Williams for facilitating the setting of the tube was used. It consists of a brass frame whose base fits snugly over the stuffing box and is securely clamped there by three set screws. The frame is slotted on each side for guiding the central tube which receives the main stem of the Pitot tube, holding it in place by a large thumb screw. This central tube is threaded its full length and passes through a thumbnut set in the upper end of the frame. By turning the thumbnut the tube can be quickly and accurately set and firmly held at any desired position in the traverse. The author attributes the uniformity of readings in practically all of these traverses largely to this accurate means of controlling the positions of the impact point. The impact opening was circular, 1 32 inch in diameter, and in making a traverse the opening was kept pointing directly up-stream, its axis always parallel to the axis of the pipe.

Gauges.—The gauges used were differential in type and consisted of a double and a triple gauge. The graduations were double centimeters subdivided into tenths, so that the third place could be estimated with a fair degree of accuracy, within about one or two-tenths, equivalent to a reading closer than 0.001 of a foot. The vertical glass tubes, about 5 16 inch internal diameter, were connected at their tops so that air remained entrapped when the water rose in them, and the difference in pressure could be read upon the scale between them. The triple gauge enabled the reading of the difference of pressure between two points along the pipe and between each of these and the impact point of the tube simultaneously.

A Traverse.—*Number of Points.*—A traverse consisted in setting the impact point of the Pitot tube at seventeen consecutive positions along the diameter of the pipe and observing the gauge readings for those positions. The positions were so chosen as to be on the circumferences of eight concentric rings dividing the internal section of the pipe into eight equal areas. This method

of division was made in order to facilitate the computation of the mean observed velocities at any given section.

In traverses at the different positions along the pipe the tube was inserted at various angles with the vertical in the plane perpendicular to the axis of the pipe. As no indication of unsymmetrical distribution of velocities was observed, these angles were not recorded.

Reading the Gauge.—At every position of the tube in a traverse the columns of the gauge were read simultaneously three times at intervals of from 20 to 30 seconds. Before beginning the readings at any point from two to three minutes were allowed for the gauge to settle. In case the second reading differed greatly from the first in any given position, the first was rejected and more time allowed for the gauge to come to rest. This happened only a very few times throughout the entire series of traverses.

The differences of the means of the three readings in each column were taken as giving the correct observed differences of head.

Tube at Centre of Pipe.—At the end of the traverse, which was made continuous across the pipe, the tube was

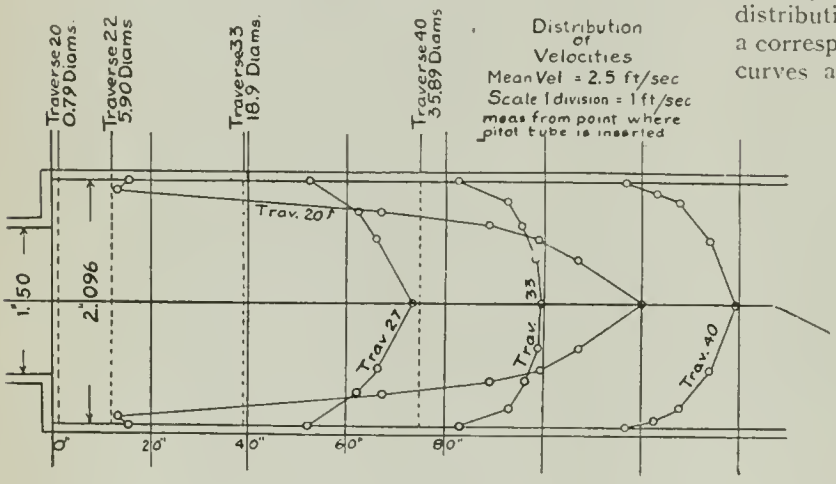


Fig. 2.

brought back to centre and the gauge readings observed as at the beginning of the traverse. This then gave three observations in each traverse with the tube on centre, at the beginning, middle and end. The mean of these three observations was taken at the true reading at the centre during the traverse.

Weighing the Water.—Weights were taken at the middle and end of each traverse as at the beginning, so that three weights were taken for every traverse. The mean of the three weights was considered as the true one from which the mean velocity in the pipe could be determined.

Time.—The time occupied for a complete traverse was about one and one-half hours.

Hydraulic Gradient.—Gradient lines have been plotted showing the observed difference of head between the different positions along the pipe below expansion for a distance of 36 diameters, Fig. 3. These curves are for velocities of one, two, three and four feet per second. The datum level or origin is the pressure at the point of expansion, and in the smaller pipe immediately above the plane of enlargement, and designated in the drawing by "E."

It will be seen that the pressure drops suddenly upon entering the large pipe, remains nearly constant for the short distance of 0.86 diameters, then begins to rise rapidly for a distance of about six diameters (12 inches). From this point the pressure begins to fall and the gradients have a slope slightly exceeding that under normal conditions, but gradually decreasing in rate of descent until at about 36 diameters below the expansion they approach very nearly the hydraulic slope of normal flow for these velocities in two-inch pipe.

It is interesting to study these curves of hydraulic slope in connection with the curves of distribution of velocities taken at the various points below the enlargement. The pressure is seen to rise most rapidly in the region where the eddies occur. There seems to be a rise in the gradient line corresponding to the amount of distortion in the curves of velocity distribution due to combined eddy formation and a retardation of the mean velocity. As the jet passes from the smaller to the larger pipe the velocity curves show first a maximum distribution at the walls and here it is that the rate of rise in the gradient is a maximum. The jet issuing from the smaller pipe is rapidly expanding with a consequent decrease in mean velocity. Farther down the pipe the velocity curves are adjusting themselves rapidly toward a more uniform distribution and in consequence the gradient line takes on a corresponding downward slope. Finally, as the velocity curves assume the form of normal distribution the hydraulic slope approaches the gradient of normal conditions of flow.

Readjustment of Velocity Distribution.—A curve of the ratios of $\frac{V_m}{V_c}$ for the various positions below enlargements was plotted in order to determine, if possible, at what position below the expansion the flow becomes normal. It is interesting to note that the conditions of velocity distribution adjust themselves to the form of normal flow in straight pipe at approximately the same distance below the disturbance in the case of sudden enlargement as in that of contraction, in the neighborhood of 35 to 40 diameters below the enlargement.

Loss of Head Due to Sudden Enlargement.—The theoretical loss of head due to sudden enlargement of section may be expressed by the equation, $H_b = \left(\frac{A_c}{A_1} - 1\right)\frac{V_2^2}{2g}$ known as Borda's formula. A_2 and A_1 are the areas of the larger and smaller pipes, V_2 is the mean velocity in feet per second in the larger pipe, $g = 32.2$, and h the loss of head in feet.

The *observed* loss of head due to sudden enlargement of section may be expressed by the aid of Bernoulli's Theorem for steady flow between any two positions in a level line as follows: $h_1 + \frac{V_1^2}{2g} = h_2 + \frac{V_2^2}{2g} + H_f + H_e$, where $h_1 + \frac{V_1^2}{2g}$ is the total effective head, the sum of the pressure and velocity heads, at any definite point in the up-stream section, $h_2 + \frac{V_2^2}{2g}$ the total effective head at any point in the down-stream section, H_f the frictional loss between the two points, and H_e the loss, indirectly observed, due to sudden enlargement.

Since $h_1 - h_2$ may be observed, the expression may be written, $h_1 - h_2 + \frac{V_2^2 - V_1^2}{2g} - H_f = H_e$, where H_e

may be considered as the *observed* loss due to the enlargement, providing H_f, the loss due to friction, be considered as known and equal to the loss for straight pipe with undisturbed flow.

H_f cannot otherwise be separated from H_e for the reason that the conditions of which H_e is a result are modifying the flow in such a way as to affect the frictional coefficient, H_f. It seems better then, to charge up to the left-hand member of the equation the term H_f, assigning to it the usual values for frictional loss in straight pipe at the various observed velocities, thus leaving the right-hand member of the equation, H_e, as the total result of the effects due to the enlargement, and of finally comparing this result with the theoretical loss expressed in Borda's formula.

to obey this law perhaps on account of conditions which might be considered as producing a water-cone of gradual instead of sudden enlargement.

The writer prefers the latter theory as a possible explanation rather than the former, for it is difficult to imagine any reduction in frictional resistance less than that for straight pipe in the region of these greatly disturbed conditions.

The position of Piezometer 5, 6 feet below the enlargement, was selected as the down-stream point for observation, and Piezometer A as the up-stream point (see Fig. 1) in order that all the losses due to the disturbance might be included. The velocity curves of distribution as shown by the Pitot tube observations indicate that

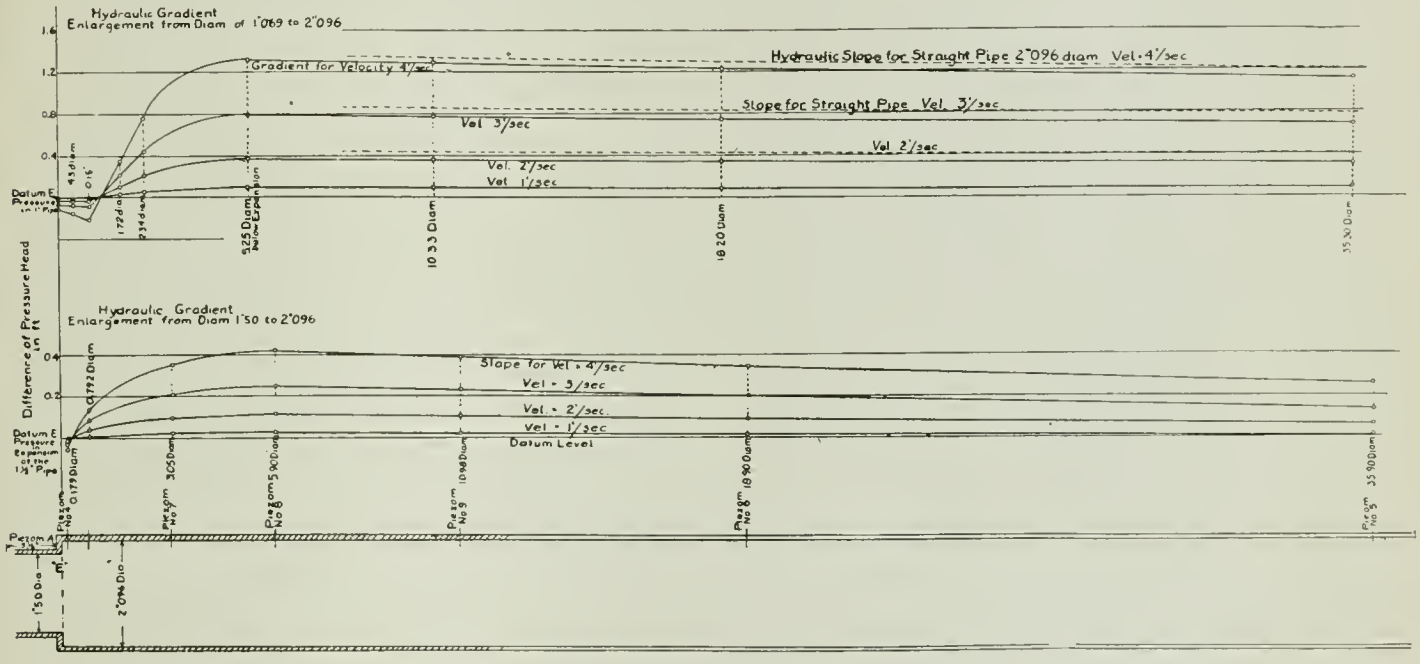


Fig. 3.

If the first member of the equation, $h_1 - h_2 + \frac{V_1^2 - V_2^2}{2g} - H_f = H_e$, be considered as the indicated loss of head between any two points, then the expression may be written $h_1 - h_2 + \frac{V_1^2 - V_2^2}{2g} - H_f = K\left(\frac{A_2}{A_1} - 1\right)^2\frac{V_2^2}{2g}$, where K is a coefficient to be applied to Borda's formula.

The accompanying tables have been prepared in which the last column of ratios gives the value of K. The tables show a slightly less loss of head thus indirectly observed than the computed theoretical loss due to enlargement as expressed by Borda's formula. This discrepancy may be due to one or two causes or perhaps a part due to each. Either the frictional loss expressed in the term H_f is less than occurs in the case of straight pipe with undisturbed flow, due perhaps to the high central velocity of the jet as it enters the larger pipe and continues in this condition for some distance before spreading out and obtaining its full pressure and frictional effect on the wall of the pipe, or else the loss in the impact of the particles in the expanding jet due to the enlargement of the pipe-section does not follow exactly the law for sudden enlargement as expressed in Borda's formula, $\left(\frac{A_2}{A_1} - 1\right)\frac{^2V^2}{2g}$ failing

most of the disturbance has been eliminated in this distance.

A correction might be applied for the effects due to the piezometers themselves in the battery just below the enlargement. That there is a slight excess loss of head due to the battery was found by Messrs. Utz and Ellis in their experiments upon the Effects of Contraction in which they used the same battery of piezometers. However, this slight loss of head, if applied as a correction, does not relieve the conditions above, but rather augments the discrepancy. The excess loss due to the presence of the piezometers is very small, and was obtained by placing the battery of piezometers, No. 5 to No. 7, in a line of straight pipe of the same diameter as that of the battery, thus eliminating all other disturbances than those due to the piezometers themselves. The distance from piezometer No. 7 to No. 5 is 5.75 feet. The formula for the total loss of head in this section as determined by Messrs. Utz and Ellis was $h = 0.268\ V^{1.75}$ in feet per 100. The excess loss of head due to the battery length then is found to be .001, .005, .016, and .026 feet for the respective velocities of 1, 2, 3 and 4 feet per second. Applying these corrections to the column in the tables, H_e, the loss due to the enlargement is further decreased and the coefficient K in the last column consequently decreased. This affects the coefficient K due to the enlargement to such a small amount, however, that it is thought better to leave the

values as they are given in the tables, and to consider the losses as due solely to sudden enlargement.

Upon examination of the curves of Hydraulic Gradient, as shown on Fig. 3, it is evident that the observations for loss of head due to the enlargement must include a length of at least 35 diameters of the larger pipe on the down-stream side. Since the effect of the disturbances dies out so gradually it appears that a length of 50 diameters might better be chosen in order to insure that all of the loss due to the enlargement be included in the observations.

The mean value of the coefficient K in the case of enlargement of pipe from one inch to two inches diameter is found from the results given in Table I. to be 0.967.

In the case of enlargement from 1½ inches to 2 inches diameter the value of K obtained from the table is approximately 0.98.

Had the excess frictional loss of head due to the presence of the piezometers previously referred to been applied these values of the co-efficient K would have been slightly reduced by an amount in no case exceeding one and one-half per cent.

Conclusions.—The final results obtained in this investigation may be briefly summarized as follows:—

1. The Pitot tube measures with a fair degree of accuracy, always within two or three per cent. and more frequently within one per cent., the velocities of flow in a pipe where the resultant motion of the water throughout

Loss of Head Due to Enlargement.

Pipe enlarged from 1.069 inches to 2.096 inches diameter.
Length of section below enlargement, 6.16 ft. 35.3 diameters.

TABLE I.

V_2 mean velocity by weight in 2″ pipe. Ft. per sec.	$h_1 - h_2$ observed loss of head in section (E—5). Feet.	$\frac{V_1^2 - V_2^2}{2g}$ loss of velocity head. Feet.	$\frac{V_1^2 - V_2^2}{2g} + (h_1 - h_2)$ total loss of head in section (E—5). Feet.	H_f loss of head straight pipe length 6.16′ Feet.	H_e loss due to enlargement (4) — (5) Feet.	$H_b \left(\frac{A_2}{A_1} - 1\right)^2 \frac{V_2^2}{2g}$ Borda's formula for loss due enlargement. Feet.	K Coefficient $= \frac{H_e}{H_b}$
3.419	—0.908	2.500	1.592	0.147	1.445	1.469	0.985
3.375	—0.903	2.420	1.517	0.143	1.374	1.435	0.958
3.325	—0.820	2.360	1.540	0.139	1.401	1.400	1.000
3.175	—0.583	2.155	1.372	0.129	1.243	1.270	0.978
3.072	—0.731	2.021	1.290	0.121	1.169	1.189	0.984
2.708	—0.575	1.575	1.000	0.098	0.902	0.924	0.978
2.427	—0.465	1.264	0.799	0.080	0.719	0.742	0.969
2.053	—0.335	0.908	0.573	0.060	0.513	0.530	0.970
2.029	—0.329	0.885	0.556	0.059	0.497	0.519	0.958
1.700	—0.229	0.620	0.319	0.043	0.348	0.364	0.957
1.584	—0.198	0.552	0.354	0.040	0.314	0.310	0.994
1.397	—0.154	0.424	0.270	0.031	0.239	0.245	0.976
0.903	—0.064	0.175	0.111	0.015	0.096	0.103	0.933
0.758	—0.016	0.124	0.108	0.011	0.097	0.107	0.910
						Mean	0.967

Loss of Head Due to Enlargement.

Pipe enlarged from 1½ ins. to 2.096 ins. diameter.
Length of section below enlargement 6.27 ft. 35.9 diameters.

TABLE II.

V_2 mean velocity by weight in 2″ pipe. Ft. per sec.	$h_1 - h_2$ observed loss of head in section (E—5). Feet.	$\frac{V_1^2 - V_2^2}{2g}$ loss of velocity head. Feet.	$\frac{V_1^2 - V_2^2}{2g} + (h_1 - h_2)$ total loss of head in section (E—5). Feet.	H_f loss of head straight pipe length 6.16′ Feet.	H_e loss due to enlargement (4) — (5) Feet.	$H_b \left(\frac{A_2}{A_1} - 1\right)^2 \frac{V_2^2}{2g}$ Borda's formula for loss due enlargement. Feet.	K Coefficient $= \frac{H_e}{H_b}$
3.881	—0.275	0.666	0.391	0.175	0.216	0.216	1.000
3.722	—0.257	0.613	0.356	0.158	0.198	0.199	0.995
3.247	—0.184	0.465	0.281	0.131	0.150	0.151	0.993
2.640	—0.125	0.307	0.182	0.087	0.095	0.099	0.960
2.214	—0.083	0.215	0.132	0.065	0.067	0.070	0.958
2.099	—0.079	0.193	0.114	0.058	0.056	0.063	0.890*
1.690	—0.049	0.125	0.076	0.041	0.035	0.041	0.854*
1.572	—0.048	0.109	0.061	0.035	0.026	0.035	0.744*
1.253	—0.024	0.069	0.045	0.023	0.022	0.022	1.000
0.970	—0.014	0.047	0.033	0.016	0.017	0.013	——*
0.802	—0.008	0.028	0.020	0.011	0.009	0.009	1.000
						Mean	0.987

*Rejected.

the entire cross-section at the point where the tube is inserted is a forward motion, and where the distribution of velocities is symmetrical about the axis of the pipe.

2. The Pitot tube is a means by which eddies or whirls caused by obstructions in the pipe may be detected, but it will not measure with any degree of accuracy the discharge of a pipe when inserted in the immediate region of such eddies.

3. The rating coefficient of discharge of the Pitot tube for normal conditions can not be applied in the case of abnormal conditions produced by sudden enlargement where eddies exist, but immediately below the region of eddies the rating coefficient of discharge may be applied with a fair degree of accuracy.

4. The eddies produced by sudden enlargement of section extend for the short distance of only about two or three diameters below the enlargement.

5. The disturbance caused by sudden enlargement of section produces abnormal conditions in the distribution of velocities which continue down the pipe for a distance of about 35 diameters.

6. The ratio of the mean velocity to the velocity at the centre, $\frac{V_m}{V_c}$, increases in value, in the case of sudden enlargement, from a minimum near the point of enlargement to a maximum at a point about 11 diameters down-stream, after which it begins to gradually decrease, approaching the value of the ratio for flow in straight pipe at a distance of 35 diameters below enlargement.

7. The loss of head due to sudden enlargement may be expressed by the equation, $H_b = K\left(\frac{A_2}{A_1} - 1\right)\frac{^2V^2}{2g}$ a constant times the theoretical loss by Borda's formula, and in making the observations for the total loss due to this disturbance, a distance of at least 35 diameters of the down-stream section, below the enlargement must be included.

The value of the coefficient K is very nearly the same in the two cases of enlargement herein investigated, and is approximately 0.97.

8. The Pitot tube reversed, i.e., the impact-point turned down-stream, gives a negative pressure-head, which reduced to velocity, negative, gives a value whose ratio with the velocity in the up-stream direction is fairly constant for any given form of tube. But the relative values of the down-stream readings to the up-stream readings for different forms of tubes vary greatly. The maximum negative pressure or suction action at the impact-point of the Pitot tube occurs when the direction of the axis of the opening is approximately perpendicular to the direction of flow.

MINERALS OF NEW BRUNSWICK.

The minerals of New Brunswick, developed and undeveloped, cover a considerable range. They include an antimony deposit at Lake George, which has recently been taken over by the Northern Antimony Smelting Company with a capitalization of $2,000,000; bituminous coal deposits (estimated to contain fifteen million tons); iron, gypsum, oil shales, manganese, graphite, tungsten, molybdenite, copper, lead, zinc, galena, barytes, infusorial earth, black, grey and red granites, freestone, sandstones and other minerals, which offer a very attractive field for investment. A discovery of a rich bed of galena ore was recently made at Maple Grove, York County, by W. H. Griffin, a provincial game guide. Two veins of 22 feet and 12 feet respectively have been uncovered. Ontario parties have secured an option of the mine.

SOME ADVANTAGES OF REFINED COAL TAR FOR ROAD CONSTRUCTION AND MAINTENANCE.*

By Philip P. Sharples,
of the Barrett Company, New York.

THE success of simply surface treatments over waterbound macadam in resisting modern state highway traffic has led in the last few years to a reversion to the macadam type to meet the needs of the lesser traffic roads. Its ease of construction and its adaptability to repairs, widening and reconstruction, commend themselves to the thinking engineer.

The choice of bituminous materials for protecting the surface lies between those which form distinct mats and those which are thin enough to enter into the surface of the roadway and form an integral part of it.

As mat-forming protectors, both asphalts and tars are available, refined to suitable consistencies. They must, however, be handled with extreme care to avoid the formation of a movable mat which ruts and rolls under traffic.

Excellent examples of this form of mat surface long in use are to be seen in the vicinity of Boston. A section of the Newton Boulevard opposite the Brae Burn Club has never been re-treated since the original three-quarters of a gallon of refined tar to the square yard was given in 1906. As the road receives heavy auto traffic, several thousand cars per day, it probably represents as low an upkeep cost for a road kept in perfect condition as any in the United States. The traffic is, however, wholly automobile and the road and its surface as perfect as could be presented for this form of treatment.

The Massachusetts State Highway at West Lynn and the Metropolitan Parkway through Everett and Revere are other examples dating from 1907 and 1906 of the success of this treatment under favorable road and traffic conditions.

The employment of bituminous material applied cold to the macadam surface has to a large extent taken the place of the hot applications. The ease and cheapness of application and the less skill required in their use have been responsible for the wider extension of cold applications.

The refined tars used for cold application have much more penetrating power than any of the other bituminous materials of an equal viscosity. This penetration makes them particularly valuable where it is important to avoid the formation of a distinct mat owing to traffic conditions which would disrupt a mat if formed. It also makes them of the greater value in treating bituminous macadam of every type. The refined tar finds its way into the surface and has a healing effect even on a distinctly disintegrating road.

The amount of bituminous material required will usually vary from ¼ gallon per square yard for re-treatments to ¾ of a gallon per square yard for new absorptive roads. The most favorable results on a first treatment can be obtained by supplying sufficient bituminous material to cause a slight excess to remain on the surface after it has been allowed to dry in for an hour or so. Usually better results are obtained on new work by applying in two treatments at an interval of two to six hours.

The kind of cover to be used depends largely on the local material available. With the refined tars, success may be obtained with a large variety of materials from three-quarter inch stone chips, through the gravels to a

*Abstract of paper read before American Association of State Highway Officials, December 6th, 1916.

fine, though sharp, sand. Materials containing clay are barred as its presence tends to cause disruption of the surface through the emulsifying properties of clay and water on bitumens.

The cost of these surface treatments vary with freights and localities, but the contract prices in Maryland, showing a total cost of between 6 and 7 cents per yard, give a good idea of the cost of doing work carried out on a large scale with power trucks in the best possible manner using stone chips for cover.

The point where it becomes desirable from an economic and engineering standpoint to build a bituminous macadam instead of a plain macadam with a surface treatment is not easy of determination. Theoretically, the decision should rest on the ability of the road to resist internal wear. The surface coatings, if kept intact, preserve the road from wear from the top but they do not prevent wear within the road itself. This internal wear has long been understood in England but has been given little study in this country.

If the loads on a macadam road increase beyond the ability of the structural strength of the road to bear them, the stone move on each other and internal disintegration takes place. With soft stone and heavy loads, a road will quickly wear out from within even though the surface is protected by treatment.

Any approach to the point where this wear becomes a serious menace to the life of the road would indicate the advisability of introducing a bitumen into the structure of the road to prevent interstitial wear.

The bitumen may be introduced either by the mixing method or by the penetration method. The less expense of the penetration method, the ease of handling the bitumen, especially if refined tar is used, the less skilled workmen required, and its peculiar adaptability to state highway conditions would warrant its wider adoption. Theoretically, the method is not perfect; practically, under ordinary conditions, it meets every requirement.

The difficulties which engineers have had with the penetration method have arisen less through the faults of the bitumens applied than through neglect of some of the fundamental tenets of macadam road construction. That is the reason that the greatest success of the penetration work has been achieved in New England and especially in Massachusetts where macadam road work has been practised in an understanding way for a generation. Some credit should also be given to a knowledge of tars in road work for the New England tar and gravel sidewalk has made the use of tar for road purposes familiar to every New England road man.

Bituminous macadam roads require, even more than plain macadam, strict attention to drainage both underground and surface. It is folly to construct a bituminous macadam without strict attention to drainage.

The base course will vary with soil and load conditions from four to eight or even ten inches. The deeper bases must be laid in layers as it is difficult to roll more than 4 inches of loose stone and consolidate it. The base course should be built like a one-course macadam rolled dry and then filled with stone screenings or gravel. The filler has the double purpose of making the base more solid and of preventing the bitumen from draining away from the top course where it belongs into the base where it is not needed.

The stone for the bituminous course, which is usually 2½ inches rolled, must be carefully selected to get clean stone, in fact much of the success of the pavement depends on the cleanliness of the stone, its proper sizing, and its proper rolling.

The size of the stone and the method of putting the top together depend much on the softness of the stone, its form of fracture, and its action under the roller. As a general rule, a soft stone should be of larger size, even up to 3 inches, than hard trap rocks. With the hard rocks, it is often necessary to add smaller sizes of clean stone in order to form a proper surface for the reception of the bitumen.

The course must be rolled enough to key the stone together and obtain structural strength, but extreme care must be exercised, especially with soft stone, not to roll it so much that the surface is closed against the entrance of bitumen. Work with asphalts and work in cold weather require a more open top than work in hot weather. In fact, care must be taken in extremely hot weather not to let the bitumen run through to the top of the base course, leaving the top course deficient in bitumen at the surface.

The amount of bitumen is, roughly, one gallon for each inch in depth of rolled stone but this quantity should include the seal coat. Usually, one and one-half to one and three-quarter gallons are used in the first coat and one-half to three-quarters of a gallon in the seal coat, for a 2½-inch top.

The bitumen is applied best by pressure apparatus of some kind. A very simple one adaptable to refined tars delivered in tank cars has been devised, using steam pressure from a road roller on the refined tar in a tank wagon and forcing it out under pressure through a single spraying nozzle. The success of the method depends on the man at the nozzle but it is not difficult to train a man to do good work, and a little extra bonus usually keeps him on the job.

After the first coat of bitumen, clean three-quarter-inch stone are cast over the surface to chink the voids. The road is then thoroughly rolled and any excess of chinking stone removed by sweeping with push brooms.

The seal coat is applied in the same way and then clean peastone cast over the surface and rolled in.

If the stone is soft, the road is finished with clean peastone. If it is hard stone, especially on light traffic roads, it is best to follow the clean peastone with stone dust. The surface voids are in this way more completely filled.

The unique property of refined cold tar of sticking to cold stone makes it especially valuable in penetration work. The hot spray striking a cold surface sticks and even a slight amount of moisture does not prevent adhesion. Coupled with this, the coal tar bitumen has strong cohesion so that even though coated surfaces be disturbed, the pieces upon being brought together reunite.

These rather striking properties allow considerable latitude in penetration work and it is not impossible, if due care is used, to build good pavements even in freezing weather.

The possibility of building macadam roads with stone not previously considered available should also be kept in mind. The cementitous qualities of a rock so necessary in waterbound macadam may be neglected, and really successful roads may be built out of flint, quartzite and granite of very low cementing values.

Some soft rocks are also made available, especially where not subjected to much rainfall. Roads built of the soft adobe rock in the vicinity of San Antonio, Texas, and protected with refined tar have been markedly successful. Experiments at Phoenix, Arizona, with caliche gravel show equal promise.

The scope of road engineering is rapidly widening and the study of the possibilities of available local materials must always be a fruitful field to cultivate.

Editorial

DEPRECIATION.

Depreciation is a term for which there does not appear to be any universally accepted definition, although the importance of depreciation as a factor in the operating costs of any power plant, pumping plant and machinery and in buildings generally has always been recognized.

Is it too much to say that engineers and managers have in the past not recognized this factor sufficiently?

Failure to appreciate the inexorable law that apparatus of all kinds must come to the end of its useful life has resulted in the financing of economically unsound enterprises of all kinds and in the embarrassment of good enterprises through the distribution to stockholders of funds that should have been held in reserve for maintenance.

Difficulties arising from lack of funds with which to provide replacements are often responsible for poor service.

It is obvious that deterioration, visible or invisible, is going on continuously. Engineers, therefore, must not fail to note the distinction between depreciation and maintenance.

The length of useful life of any unit is determined by one or both of two factors: First, the inherent quality of most physical property to deteriorate owing to use and to the elements until it reaches such a condition that it is either impossible to keep it in satisfactory operative condition by repair or the cost for such repairs becomes so great that it would be more economical to replace it by a new one.

Second, the changes in the art whereby the character of the service required is so changed that it becomes obsolete.

The rate to be allowed for depreciation must be largely governed by local conditions and will vary according to the utility. Depreciation is a constant loss and should be reckoned with.

ESTIMATE vs. TENDER ON CIVIC WORK OPEN TO CONTRACT.

The practice of city engineering departments competing with contractors on public works is becoming more general and in a number of ways this is to be welcomed. It serves as a preventative against a possible agreement among contractors in the matter of prices or conditions of work. Another good effect is that it acts as a stimulus to the municipal engineering staff. When the onus is thus placed upon the staff of competing with outside concerns it tends to keep it more efficient and at the same time keeps the price of general construction work more nearly where it ought to be.

On the other hand, in not many cities in Canada is the engineering department so well organized as to be in a position to better carry out such work (with the exception of perhaps extensions to water mains, sewers, pavements, etc.) and at a lower cost than the responsible contractors who bid for it are in a position to do. Questions of plant, labor and experience are usually in favor of the contractor.

This raises the question as to the advisability of getting a tender from the city engineering department on work to which the above conditions apply. If it be the lowest it ought to be accepted under the competitive plan. If, on the other hand, the engineer's tender is to be merely used for the purposes of comparison is not the same object obtained by the submission of an estimate?

It is claimed by many that the municipal engineer has many opportunities for so distributing his charges as to make the ultimate cost of a particular piece of work amount to any figure he desires within reasonable limits.

There would appear to be many pieces of work concerning which an estimate would answer the same purpose as a competitive tender and leave to contractors the tendering for work which they are better equipped to carry out.

This would have the effect, however, of being less beneficial so far as stimulus to the engineering staff is concerned. However, an intelligent combination of the two would add to the efficiency of the city engineer's department without losing the advantage of being able to check contract prices, and without being as unfair to the contractor as engineers' bids occasionally have been.

AIDING THE PROFESSION.

During the past few months the status of the engineering profession has been very frequently discussed in scientific spheres. Not a few papers have been read before various technical societies on the subject and these have brought out much discussion as to how engineering might be aided to come more nearly into its own as a profession.

The engineer is the man who is expected to do things, and in most instances he does not disappoint. The thing accomplished, he is disposed to say little or nothing about it. This trait in him is to be commended, but may not always be the wisest procedure to follow. If this is persisted in it may well be doubted that the general public will ever have clear-cut ideas as to the real importance of the engineer in the community.

The fact that these questions are forcing themselves upon the membership of the profession is in itself a hopeful sign. It does really seem as if the desire to do more in the way of mutual assistance of one another in the engineering profession was gaining ground.

There are wonderful engineering possibilities in Canada and unlimited scope for the engineer. Problems are facing us as a people and will continue to face us in the solution of which the engineering profession will have a large part to play. It is fitting, therefore, that every member of the profession do his share in an effort to assist it to attain that position which it should rightly occupy.

ENGINEERS WILL OFFER SERVICES.

In our issue of last week under the heading "Engineers Will Offer Services," we reported an open meeting that had been held at the Engineers' Club, Toronto, of members of the local branches of the technical societies in that city. At that meeting a committee was appointed composed, in the main, of one member of each of the various technical organizations having members in Ontario.

This committee met on Tuesday evening, January 2, and discussed at length various lines of action that seemed to offer promise of real and useful results in the way of hastening our victory in the war. Professor J. C. McLennan, who is also a member of the recently appointed Industrial Research Advisory Council, outlined the work that body is planning and expressed the belief that the committee of engineers could work best through this Advisory Council, at least for the present. This plan commended itself to the committee and in all probability developments will follow along that line.

PROPOSED SPECIFICATIONS FOR HIGHWAY BRIDGES.

In our issue of December 21st, 1916, an article appeared under the above title. This dealt with the proposed recommendations of the Committee of the Canadian Society of Civil Engineers on Highway Bridge Specifications. As the article might be construed as outlining the final recommendations of the committee, we desire to correct that impression. The discussion, a report of which we published in the article in question, was precipitated by a paper which was prepared by Mr. P. L. Pratley and read by Mr. G. H. Duggan, which contained certain suggestions as to highway bridge design. These suggestions, however, may and may not be adopted by the committee. The draft of the specifications as proposed by the committee is still subject to revision, and is quite different from those embodied in our article of December 21st.

PERSONAL.

A. C. GARDEN has been elected chairman of the Hamilton Harbor Commission for 1917.

A. A. COLE, president of the Canadian Mining Institute, has been nominated for re-election.

A. INGRAM, superintendent of the electric light and water commission, Kincardine, Ont., has resigned.

ROBERT PARKER, a contractor of Windsor, Ont., has been appointed building inspector for that city.

D. M. MAWHINNEY, formerly with the Winnipeg, Selkirk and Lake Winnipeg Railway, has been appointed engineer for Rockwood municipality, with offices at Stonewall, Man.

Lieut. JAMES CAMERON ARMER, of the Commercial Press, Limited, Toronto, has been appointed recruiting officer for the Canadian Engineers in Military District No. 2, Toronto, vice Lieut. M. B. DUTHIE.

LAWRENCE T. MARTIN, a member of the firm of O'Brien & Martin, railway contractors, Renfrew, Ont., has been appointed commanding officer of the Railway Construction Battalion to be formed in Canada for service in France.

LORD COWDRAY, formerly Sir Westman Pearson, president of S. Pearson & Sons, Limited, contractors, London, England, has been appointed chairman of the Army and Navy Airplane Service Board, in succession to Lord Curzon.

W. W. BUTLER, heretofore senior vice-president of the Canadian Car & Foundry Co., Limited, Montreal, has been elected vice-president and managing director, and W. S. ATWOOD, heretofore chief engineer and general works manager, has been appointed operating manager.

Lieut. CUTHBERT P. COATSWORTH, son of his Honor Judge Emerson Coatsworth, Toronto, has been awarded the Military Cross. He is 22 years of age, and was a second year student at the School of Practical Science when he joined the 2nd Canadian Pioneer Battalion, with which he went overseas.

JOHN I. REID has been appointed superintendent of the Longue Pointe plant of the Canadian Steel Foundries, Limited, Montreal. He was formerly works manager of the American Steel Foundries' plant at Chester, Pa., and recently sales agent for the company at 30 Church Street, New York City.

Major LINDSAY MALCOLM, A.M.Can.Soc.C.E., of the Canadian Engineers, who at various times acted as city engineer at Guelph, Ont., in the absence of the regular engineer, and who went overseas in command of an engineering company from Queen's University, Kingston, received honorable mention in the latest dispatch of General Sir Douglas Haig.

Lieut. ROBERT L. DUNSMORE, of St. Thomas, Ont., who was wounded last July, has been awarded the Military Cross for bravery under fire. He is a civil engineer by profession, and a graduate of Queen's University, Kingston, Ont. He volunteered for active service four days after the declaration of war, and went overseas with an engineering unit in the Second Division. Since he has been at the front he has suffered from an attack of typhoid fever.

Lieut. C. AUSTIN BELL, son of Chas. H. Bell, 427 Sumach Street, Toronto, is reported to have been awarded the Military Cross for bravery in action. Lieut. Bell, who is 25 years of age, enlisted as a private in the Engineers, and won his commission on the field. He was twice wounded, once at Langemarck and once at Ypres. After convalescing in a Boulonge hospital he returned to the front. He is a graduate of the School of Practical Science and before enlisting was employed as a mines maintenance engineer with the Canadian Copper Co.

OBITUARY.

Lieut. CHARLES THURSTON BOWRING, of the Canadian Machine Gun Company, a member of the late firm of Bowring & Logan, electrical engineers, Winnipeg, was killed in action on December 29.

Lieut. GERALD GALT, a graduate of the School of Practical Science, Toronto, and who for many years prior to enlisting was a mining engineer in Chile, South America, is reported to have been instantly killed on Christmas night. Lieut. Galt went to the front early last year with the 3rd Tunnelling Corps. He was about 29 years of age.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

CANADIAN SOCIETY OF CIVIL ENGINEERS

THIRTY-FIRST ANNUAL MEETING TO BE HELD AT MONTREAL NEXT TUESDAY, WEDNESDAY AND THURSDAY—SUMMARY OF ACTIVITIES FOR PAST YEAR AND BUSINESS TO BE CONSIDERED NEXT WEEK.

CONFIDENT in the future of Canada and the Empire, determined to do their duty in avenging devastated Belgium, and proud of the part their profession has played in the war, the civil engineers of Canada will assemble in annual gathering at Montreal next week for the third time during the struggle, and for the thirty-first time in the history of the Canadian Society of Civil Engineers. The meeting will be held in the Society's building, 176 Mansfield Street, Montreal, and it is expected that several hundred engineers will be there.

Lieut.-Col. John Stoughton Dennis
President-Elect.

George Herrick Duggan
Retiring President

The first session will open at 10 a.m., Tuesday, January 23rd, with the reading of minutes and the appointment of scrutineers. The reports of council, library committee, treasurer and finance committee will be received. After hearing the reports of branches, the meeting will adjourn at 1 p.m. for two hours.

In the afternoon session, the reports of the following committees will be discussed: Conservation, Roads and Pavements, International Electro-technical Commission, Steel Bridge Specifications, Educational Requirements, Sewage Disposal and Sanitation, General Clauses, and Steam Boiler Specifications.

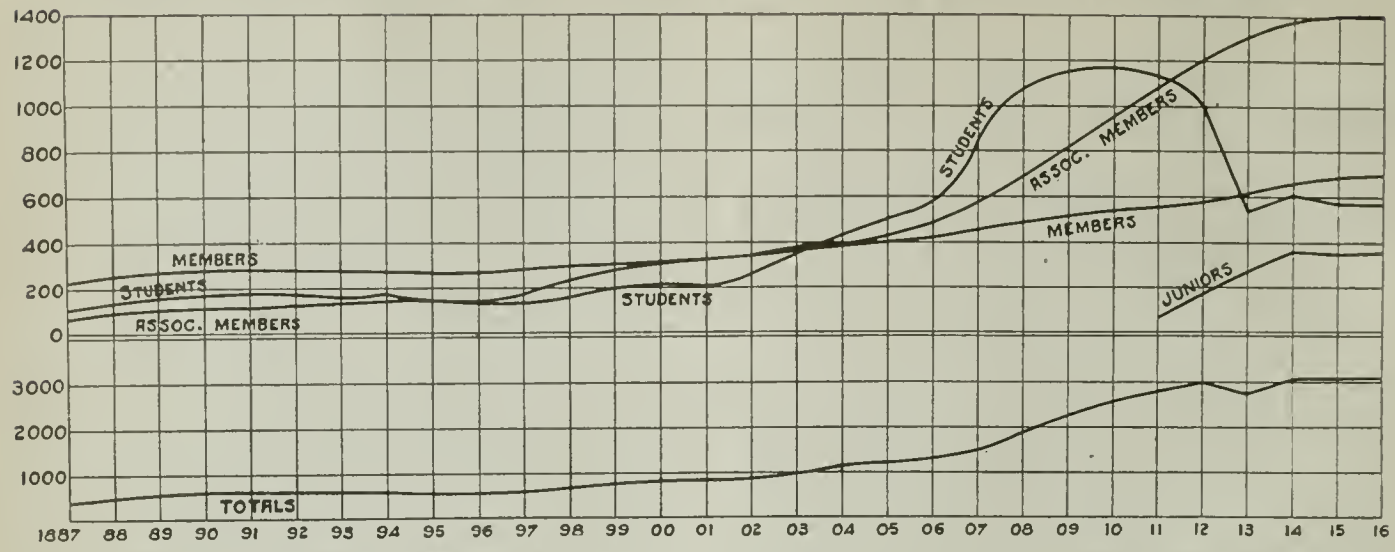
At 7 p.m. an informal dinner, complimentary to visiting members, will be given in the University Club, followed at 8.30 p.m. by an entertainment and smoker in the auditorium of the Society's building.

Inspection trips to various points of interest (including the munitions plants of the Dominion Bridge and subsidiary or allied companies) will be enjoyed Wednesday morning, and in the afternoon the members will continue to receive reports of committees and to act thereon. At 4.30 p.m. the retiring president will deliver an address.

At ten o'clock Thursday morning the members will meet to elect officers and councillors. The newly-elected president will take the chair, after which various new and unfinished business will be discussed, completing the annual meeting. In the afternoon there will be a session of the new council.

By courtesy of the Eastern Canadian Passengers' Association, members and their families who have paid a full one-way first-class fare going to the meeting, will be

CURVES SHOWING GROWTH OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.



Top Curves Show Growth of Each Class of Membership. Bottom Curve Shows Growth of Total Membership.

returned free on presentation of a standard convention certificate signed by the ticket agent from whom the one-way ticket was procured. This is regardless of the number in attendance at the meeting.

The Retiring President—This annual meeting will mark the retirement from the presidency of GEORGE HERRICK DUGGAN, vice-president and general manager of the Dominion Bridge Co., Montreal. Mr. Duggan was elected to associate membership in the Society in 1888, and two years later qualified as member. He is a member of the Institution of Civil Engineers of Great Britain, the American Society of Civil Engineers, and the Canadian Mining Institute. He was vice-president of the Canadian Society of Civil Engineers in 1900, 1901, 1903 and 1908, and also served as councillor for the years 1894, 1896, 1898, 1899, 1904, 1907, 1912, 1913 and 1914.

Mr. Duggan is an enthusiastic sailor and was one of the founders of the Toronto Yacht and Royal St. Lawrence Yacht Clubs. He designed and sailed the winner of the Seawanhaka International Cup and successfully defended that prize from 1896 until 1901.

He was born in Toronto September 6th, 1862, the only son of the late John Duggan, Q.C., and Amelia (Tulloh) Duggan. He was educated at Upper Canada College, Toronto, and at S.P.S., Toronto University. He began his engineering career with the C.P.R., but in 1886 entered the employ of the Dominion Bridge Co., becoming chief engineer in 1891. In 1902 he became assistant to the president of the Dominion Iron & Steel Co. and in 1904 was appointed second vice-president and general manager of the Dominion Coal Co., but six years later he rejoined the Dominion Bridge Co. as general manager.

He is vice-president of the Montreal Ammunition Co., president of the Dominion Copper Products Co., director of the Royal Bank of Canada, director of the Montreal Trust Co., director of the Hillcrest Collieries, and chief engineer of the St. Lawrence Bridge Co., having entire charge, jointly with Mr. Phelps Johnson, of the New Quebec Bridge superstructure.

Among the clubs of which Mr. Duggan is a member are the Mount Royal, St. James, University, Engineers, and Forest and Stream, of Montreal; Royal Canadian Yacht, of Toronto; Royal Cape Breton Yacht, of Sydney; Royal St. Lawrence Yacht, and Garrison, of Quebec.

In a recent article, speaking of Mr. Duggan, the Toronto Globe said: "He carries as much sporting blood in him as can safely be carried by a man who must temper sport with business." About the same time the Canadian Century remarked: "Mr. Duggan is a big man, who, whether building bridges, managing the affairs of a huge coal mining company or designing and sailing small boats, is equally at home."

Early in the war both of Mr. Duggan's sons enlisted, one of them, Lieut. H. S. Duggan, R.E., being killed in action October 21st, 1915. Unfortunately a recent casualty list reported that the other son, Lieut. K. L. Duggan, of the Mounted Rifles, had been wounded.

The President-Elect.—Mr. Duggan will be succeeded as president by Lieut.-Col JOHN STOUGHTON DENNIS, C.E., D.L.S., D.T.S., assistant to the president of the Canadian Pacific Railway Co. Lieut.-Col. Dennis joined the Society November 21st, 1901, as a member and was a vice-president for the year 1907 and a councillor for the years 1906 and 1911. He is a past president of the American Society of Irrigation Engineers.

Lieut.-Col. Dennis was born at Toronto in 1856. His father was the late Lieut.-Col. John Stoughton Dennis, C.M.G., who was the first surveyor-general of Canada and subsequently the first Deputy Minister of the Interior. Dennis, Jr., was educated at the Toronto and Kingston Grammar Schools and Upper Canada College. He also graduated from the old military school at Kingston before the creation of the Royal Military College.

He served his articles as a Dominion land surveyor with the late Lindsay Russell, assistant surveyor-general, and was graduated and commissioned as a Dominion topographical surveyor in 1877. From 1872 to 1879 he was employed on survey work for the Dominion Government in Manitoba and the Northwest Territories. From 1879 to 1882 he was engineer and surveyor for the Hudson's Bay Co., and during that time he organized the Land Department of that company and laid out what is now the southern portion of the city of Winnipeg, constructing the first trunk sewer system in that part of the city.

In 1882 he resigned from the Hudson's Bay Co. and organized the firm of Dennis, Vaughan & Co., consulting engineers, Winnipeg, but three years later he rejoined the service of the Dominion Government as inspector of sur-

veys, becoming chief inspector in 1892. In 1896 he entered the service of the Northwest Territorial Government as chief engineer, and in 1899 became Deputy Minister of Public Works, N.W.T.

At the age of forty-six he first joined the service of the Canadian Pacific Railway Co. as superintendent of irrigation and chief engineer of the large projects then being carried out by the company in Alberta. Subsequently he was appointed C.P.R. Land Commissioner for British Columbia, and in 1904 became assistant to the second vice-president at Calgary.

In 1910 his appointment was announced as manager of the C.P.R. irrigation and land interests in Alberta, and a few years later he was appointed western assistant to the president. About November 1, 1916, Lieut.-Col. Dennis was promoted to the position of assistant to the president of the C.P.R. at Montreal, and it is expected that he will have special charge of many of Baron Shaughnessy's interests during the latter's attendance at the House of Lords in England.

As can be assumed from his title, Lieut.-Col. Dennis has had considerable experience in Canada's militia. He served as a lieutenant in the Governor-General's Foot Guards at Ottawa for a short period after leaving military school, and in 1885 he commanded, with rank of captain, the Intelligence Scout Corps attached to General Middleton's Column during the Riel Rebellion, being mentioned in dispatches for service at the Battle of Betoche. He was transferred to the reserve of officers with brevet rank of major, and last year was gazetted lieutenant-colonel commanding the Calgary battalion of the reserve militia.

Nominees for Vice-President.—Two vice-presidents are to be elected this year, and one of them must be resident in District No. 1. The nominations are: G. R. G. Conway, bondholders' representative, Mexican Light and Power Co., Mexico City; J. M. R. Fairbairn, assistant chief engineer, Canadian Pacific Railway, Montreal; J. G. Legrand, bridge engineer, G.T.P. Railway, Winnipeg; C. N. Monsarrat, chairman, Quebec Bridge Commission, Montreal. The nominees who are resident in District No. 1 are Messrs. Fairbairn and Monsarrat.

The Council.—The nominees for council are as follows (two members are elected in District No. 1 and one member from each of the other districts):—

District No. 1—J. Duchastel, city engineer, Outremont; F. H. Pitcher, chief engineer, Montreal Water & Power Co., Montreal; R. A. Ross, consulting engineer, Montreal; Julian C. Smith, chief engineer, Shawinigan Water & Power Co., Montreal.

District No. 2—Horace Longley, of Norton-Griffith & Co., St. John; C. M. Odell, resident engineer, Dominion Coal Co., Glace Bay, N.S.

District No. 3—A. R. Decary, superintending engineer of the Province of Quebec, Public Works of Canada, Quebec; S. S. Oliver, consulting engineer, Quebec.

District No. 4—John Murphy, electrical engineer, Department of Railways and Canals, Ottawa; James White, assistant to chairman, Commission of Conservation, Ottawa.

District No. 5—G. A. McCarthy, railway and bridge engineer, Works Department, Toronto; E. W. Oliver, assistant to chief engineer, Canadian Northern Railway, Toronto.

District No. 6—A. T. Fraser, district engineer, Canadian Northern Railway, Edmonton; Wm. Pearce, assistant to executive, Department of Natural Resources, Canadian Pacific Railway, Calgary.

District No. 7—R. F. Hayward, chief engineer, Western Canada Power Co., Vancouver; J. H. Kennedy, assistant chief engineer, V.V. and E. Railway, Vancouver.

Prof. Clement Henry McLeod, Ma.E.
Secretary, Can.Soc.C.E.

Quarter Century of Service

DURING the year 1916, Prof. C. H. McLeod celebrated the twenty-fifth anniversary of his appointment as secretary of the Society. When he took office in 1891—in the fifth year of the Society's existence—the total membership was only about 700. Prof. McLeod is one of the most widely known men in Society affairs. He has given a great deal of time, thought and energy to the work—energy which undoubtedly would have been more remunerative had it been turned to more utilitarian purposes. Despite the time occupied by Society affairs, however, Prof. McLeod has succeeded in scientific work, and is now vice-dean of the engineering faculty at McGill University. He is a Fellow of the Royal Society of Canada and a life member of the Royal Astronomical Society. Recognized as an authority upon astronomy, surveying and geodesy, many of his writings are used as texts in advanced courses.

Extracts from Report of Council.—Elections during the year resulted in the following additions to the roll: 18 members, 69 associate members, 2 associates, 23 juniors and 34 students. One former associate member and one former junior were reinstated.

The following transfers were made: 23 associate members to the class of member, 18 juniors and 18 students to the class of associate member, and 27 students to the class of junior.

There have been removed from the rolls by resignation or on account of non-payment of dues, 10 members, 44 associate members, 3 associates, 9 juniors and 72 students. These resignations were due either to the fact that those concerned had ceased active engineering work or were, owing to lack of employment, unable to pay the annual dues.

Thirty-nine deaths were reported during the year, including 21 who gave their lives in the defence of the Empire. Of 14 deaths among associate members, 10 were due to wounds at the front.

At present the membership is 3,047, a decrease of 29 as compared with last year. The corporate membership showed an increase of 41, and there was an increase

of 19 among the juniors. The falling off in student membership—88—more than offset the other increases, however. This falling off was due considerably to transfers to higher grades of membership.

Meetings.—The council held twenty-nine meetings during the year. There were nine sectional meetings, six monthly meetings, and one special meeting of the society. The following papers and addresses were presented at these meetings:—

"Construction of the Rogers Pass Tunnel," by J. G. Sullivan.

"The Method Employed in Designing the Foundation of the Federal Palace, Mexico," by S. J. Fortin.

"Interesting Features of Reinforced Concrete Buildings in and around Montreal," by C. M. Morssen.

"Manufacture of Brass Cartridge Cases in Canada," by H. H. Vaughan.

"Economic and Strategic Aspects of Enlargement of Welland Canal and of Construction of Georgian Bay Ship Canal," by Col. R. W. Leonard.

"The Rules and Regulations of the Province of British Columbia relating to Annual Rental Fees of Water Powers," by E. Davis.

"The Latest Advances in Bayonet Fighting," by Capt. P. E. Nobbs.

"The Design of Passenger Terminals," by J. L. Busfield.

"Electrical Precipitation of Solids from Gases," by Linn Bradley.

"The Rolling and Floating Steel Caissons of the Levis Dry Dock," by L. R. Thomson.

"The Difficulties of Earth Slides in the Culebra Cut, Panama Canal," by John Murphy.

"Description of Original Diagrams for Making Military Scales," for interpolation of contours and reduction and enlargement of maps, by Lieut.-Col. F. A. Snyder.

"The Law and the Engineer," by Geo. H. Montgomery, K.C.

Description of a series of photographs from the western battle front, by Paul A. N. Seurot.

"The Aqueduct for the Greater Winnipeg Water District," by W. G. Chace, M. V. Sauer and D. L. McLean.

"Some Phases of Railway Work at the Front," by Lieut. Paul Ogilvy.

"Experiences as a Machine Gun Officer at the Front," by Capt. Jas. G. Ross.

"Bombing in the Front Line Trenches," by Capt. G. L. Dobbin.

"The Water Supply of the City of Port Arthur," by L. M. Jones.

"The High Tension Transmission Line Towers," by L. R. Thomson.

"Aviation Work at the Front," by Lieut. E. Laurie.

"Filtration Experience," by H. G. Hunter.

Discussion on the Proposed Specifications for Highway Bridges.

Committees.— Following have been the committees of council during the year:—

Library and House (S. P. Brown, chairman), Finance (R. A. Ross, chairman), Meetings (W. J. Francis, chairman), Board of Examiners (H. M. MacKay, chairman), Gzowski Medal and Students' Prizes (Phelps Johnson, chairman).

The Nominating Committee for officers for the year 1917 were Ernest Brown (chairman); Phelps Johnson, M. J. Butler, C.M.G., and F. C. Gamble (past presidents); G. G. Murdoch, A. Tremblay, G. A. Mountain, A. F. Macallum, J. Chalmers and E. A. Cleveland.

The other committees at work during the year were as follows:—

Educational Requirements (E. Marceau, chairman),

(Continued on page 58.)

Over Twenty-Two Percent. of the Total Membership of the Canadian Society of Civil Engineers Has Enlisted

Canada's Civil Engineers Rally to the Flag

SOCIETY MEMBERS ENLISTED, C.E.F.

Hon. Members	1
Members	67
Associate Members	290
Associates	3
Juniors	135
Students	182
Total	678

SOCIETY MEMBERS KILLED IN ACTION OR DIED OF WOUNDS.

Members	4
Associate Members	14
Juniors	9
Students	6
Total	33

Eighteen Corporate Members and Fifteen Juniors and Students Have Made The Supreme Sacrifice

POINTS OF INTEREST IN CONNECTION WITH SOME CONCRETE BUILDINGS RECENTLY ERECTED IN AND AROUND MONTREAL.*

By C. M. Morssen, M.Can.Soc.C.E.

SOME of the buildings are interesting by their size and exterior finish, some by their size and time of the year at which they were erected, and others are interesting from an engineering point of view, presenting complicated problems in the design of domes, arches, cantilevers, winding stairs, towers, etc.

The Orphanage.—In 1912 an orphanage building was erected in St. Laurent for the Order of the Rev. Grey Nuns. The building is about 250 feet long, and five stories high (basement and four stories). The whole structure is of concrete.

The exterior walls are 8 ins. thick, and are lined with hollow terra cotta to the interior. The foundation walls are of plain concrete, but the footings for walls and columns are of reinforced concrete. A large amount (about 15%) of clean one-man stones were embedded in the foundation walls, which are 20 ins. thick, and although the building is three years old, the foundation walls do not show any cracks. It is the writer's opinion that the lack of cracks is due to the free and careful use of large stones. A great number of concrete buildings where large stones were not permitted, show expansion cracks, especially in the foundation walls.

The basement walls and first floor of the orphanage were built in November, December and January, 1911. The reinforced concrete floor (about 20,000 sq. ft.) was finished in freezing weather. The work was stopped and resumed in May, 1912. In the spring, the concrete (4-in. floor) was rather soft on the surface, but in about three weeks the floor became very hard and tough. As soon as the warm weather set in, the floor was freely sprinkled with water twice daily. When the concrete was laid no special precautions were taken, with the exception of making sure that the sand and stone did not contain frozen particles. The concrete was allowed to freeze, and no coverings were provided. The floor proved a perfect success.

The skeleton of this building, starting from the basement floor, is of steel. All columns and beams are fireproofed with stone concrete.

As the exterior walls are of concrete, the question of the exterior finish had to be decided upon. Several studies were made under the direction of the architect, Mr. A. Piche, and finally a small rough-cast finish was decided upon. This finish was made in the following way: The surface of the concrete was thoroughly cleaned, picked and washed. Immediately after the washing a thin layer of cement mortar (1 : 2) was applied and troweled to an even surface, and before the mortar had time to set it was picked rough with a special wooden brush. When completed, the outside finish was composed of small particles of mortar well troweled into a clean and rough concrete surface. The result is very satisfactory indeed, and the benefit of the adhesion of a well-applied mortar is obtained. After three Canadian winters not one square inch of the 7,000 sq. yds. of exterior finish scaled off, and the appearance is also very pleasant and uniform. The same method has been equally successful on other buildings.

As mentioned, several tests were made before a decision regarding the finish was reached, and a cement gun was also experimented with. The finish obtained with the cement gun was good in appearance, but the method had to be abandoned because of the very expensive scaffolding which would have been required to cover the whole building with gunite.

The ordinary way of obtaining a rough-cast was also investigated, and it was ascertained that the throwing of mortar pebbles against the wall gives an appreciable percentage of waste, and the recoil weakens the adhesion between the mortar and the concrete wall.

The Old Folks' Home.—The Old Folks' Home, built for the same Order, is of still larger proportions, being 400 feet long, and having an area of 40,000 sq. ft. per floor. This building is all of reinforced concrete. The outside walls are 9 ins. thick, and the floors are mostly made of tile and concrete. The work on the foundation was started in October, 1913, and finished in February, 1914.

The floor is made of 8-in. tile with concrete beams at 16-in. centre to centre, the whole being covered with 2 ins. of concrete.

(Continued on page 71.)

*Abstract of paper presented to the Canadian Society of Civil Engineers.

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SIR JOHN KENNEDY
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Consulting Engineer, Montreal.

Membership, Can. Soc. C. E.

	1914.	1915.	1916.
Honorary members	10	8	8
Members	674	693	709
Associate members	1,372	1,409	1,434
Associates	36	34	33
Juniors	352	357	376
Students	615	575	487
Total	3,059	3,076	3,047

ANALYSIS OF CHICAGO BY-LAW FOR FLAT SLABS

RECENT TESTS CONDUCTED IN TORONTO BY THE CITY ARCHITECT'S DEPARTMENT AND PROF. PETER GILLESPIE SHOW THAT THE CHICAGO CODE FOR FOUR-WAY TYPE OF CONSTRUCTION IS UNDOUBTEDLY CONSERVATIVE.

By WILLIAM WORTH PEARSE, C.E.,
City Architect and Superintendent of Building, Toronto.

AT the time of approving the plans for several large buildings based on the Chicago code for flat slab four-way type of construction, the writer made an analysis of the Chicago by-law which may interest *Canadian Engineer* readers.

By an examination of this analysis it will be noted that apparently the Chicago code is based on the theory of a beam of uniform section rigidly fixed at both ends. The negative bending moment for the full width of the panel over the supports would then be $-\frac{WL}{12}$; and the positive bending moment for the full width of the panel midway between the supports, $\frac{WL}{24}$.

Assuming there were two continuous beams of width L running at right angles to each other, each carrying one-half the total live and dead loads, the individual moment over the support being $-\frac{WL}{24}$, and at the centre a positive moment of $\frac{WL}{48}$.

This can readily be proved by adding together $\frac{WL}{120}$ and $\frac{WL}{30}$, the moments for the ½ panel strips called for in the Chicago code, which sum equals $\frac{WL}{24}$, and also by adding together the centre positive moments $\frac{WL}{80}$ and $\frac{WL}{120}$, which sum equals $\frac{WL}{48}$. The problem then resolves itself into determining what proportion of $\frac{WL}{24}$ and $\frac{WL}{48}$ is taken respectively by the centre and side strips.

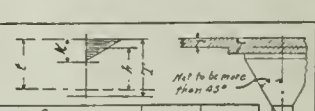
In the following analysis I have endeavored to arrive at an approximate method, which agrees in a surprising degree with what has been adopted in the Chicago code, I have assumed that the line of contra-flexure around the centre of the panel is a circle, whereas actually from experiments on a rubber slab conducted by F. J. Trelease, it is an average between a square and a circle. I have also found this to be true by a number of tests on actual structures. However, for ease in figuring I have taken the circle as a basis, and by checking a number of cases I have found that it makes very little difference in the results.

It is apparent that the Chicago code does not take into consideration Poisson's ratio, nor does it make any allowance for arch action or tension in the concrete. This, of course, gives an additional factor of safety, and from tests which have recently been conducted in Toronto by Mr. Mylrea, of the city architect's department, in conjunction with Prof. Gillespie, of the University of Toronto, the Chicago code is undoubtedly quite conservative.

After looking over a large number of discussions on the flat slab type of construction, I was unable

Maximum allowable steel stress 18000 lbs per sq inch
Maximum extreme fibre stress concrete 700 lbs per sq inch
Note: This Table is for Four Way Type of Construction only

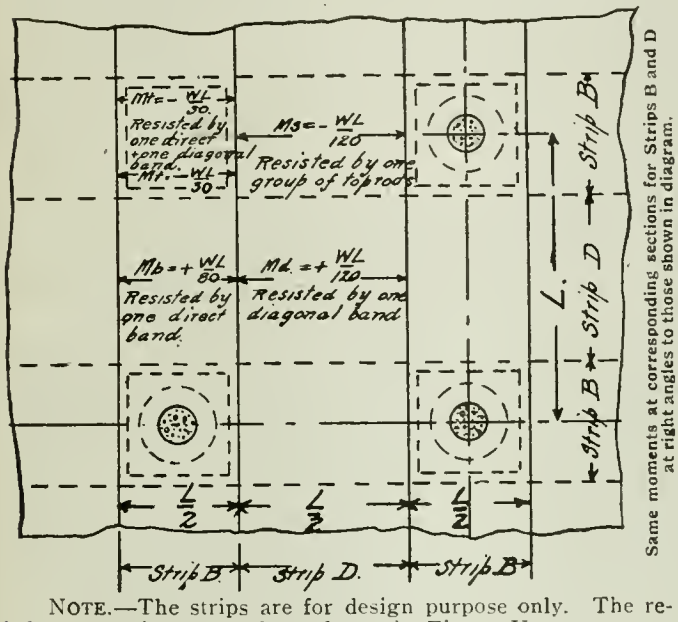
TABLE I.



1 Safe Live Load Lbs per sq ft	2 Size of Square Panel	3 Total load on one panel W	4 Diam. of Tapered Cap	5 Area of Column Cap sq ft	6 Side of Square Capital	7 Slab Thickness: Through Depression inches	Slab for Strip B inches h	Slab for Strip A inches h'	Slab for Strip B inches h''	Slab for Strip A inches h'''	8 Average dead load of Slab Lbs	9 Steel in inches in each strip: One side Strip B	One side Strip A	Both sides Strip B	Both sides Strip A	10 Load on Column Cap Wc	11 Shear on Column Cap W-Wc
40	18'-6"	30600	3'-6"	8'-0	5'-4	9 5	7.04	6.0	4.4	6.0	80 2	.93	.63	1.89	1.33	1306	29400
100	"	46000	"	"	"	9 5	7.04	6 0	4.4	6.0	80 2	1.4	.102	.102	2.32	1940	44100
125	"	52500	"	"	"	9 5	7.04	6.0	4.4	6 0	80 2	1.53	1.17	1.17	2.68	2130	50300
150	"	58800	"	"	"	9 5	7.04	6.0	4.4	6 0	80 2	1.78	1.3	1.3	2.97	2480	56300
200	"	70300	"	"	"	10 5	7.92	6 5	4.84	6 5	86 4	2.02	1.5	1.5	3.3	2900	70400
250	"	82000	"	"	"	11 5	8 8	7.0	5.28	7.0	93 5	2.22	1.63	1.63	3.56	3300	84100
300	"	104000	"	"	"	12 5	9 66	7 5	5.72	7.5	100 5	2.44	1.78	1.78	3.82	4000	100000
40	19'-6"	33600	4'-0"	11 2	5'-8"	9 5	7.04	6.0	4.4	6 0	80 2	1.24	.95	.95	2.14	1730	38100
100	"	54000	"	"	"	10	7.5	6 5	4.84	6 5	85 6	1.57	1.15	1.15	2.72	2430	51600
125	"	61000	"	"	"	10	7.5	6 5	4.84	6 5	85 6	1.79	1.3	1.3	3.08	2700	58300
150	"	68400	"	"	"	10	7.5	6 5	4.84	6 5	85 6	2.0	1.45	1.45	3.42	3000	65400
200	"	83000	"	"	"	10 5	7.92	6 5	4.84	6 5	85 6	2.42	1.77	1.77	3.96	3600	79400
250	"	100000	"	"	"	11 5	8 8	7.25	5 5	7.25	50	96 0	2.58	1.85	1.85	4.3	4300	95700
300	"	118000	"	"	"	13 0	9 9	8 0	6 0	8 0	5 66	106 5	2.72	1.95	1.35	4 5	5030	112900
40	18'-0"	32000	4'-2"	13 2	6'-0"	9 75	7.26	6.25	4.62	6.25	4.12	82 5	1.3	.93	.93	2.21	2060	38000
100	"	62500	"	"	"	11 0	8 36	7 0	5 76	7 0	5 28	92 7	1.62	1.16	1.16	2.99	3000	60000
125	"	70400	"	"	"	11 0	8 36	7 0	5 76	7 0	5 28	92 7	1.84	1.33	1.33	3 4	3340	67300
150	"	79000	"	"	"	11 5	8 8	7 0	5 76	7 0	5 28	93 3	2.05	1.46	1.46	3.6	3750	75200
200	"	93000	"	"	"	11 5	8 8	7 0	5 76	7 0	5 28	93 3	2.46	1.76	1.76	4.32	4200	90600
250	"	115500	"	"	"	12 5	9 66	8 0	6 16	8 0	5 66	105 8	2.83	2.02	2.02	4 8	5220	110300
300	"	134000	"	"	"	13 5	10 12	8 5	6 6	8 5	6 1	111 2	3 05	2 18	2 18	5 3	6000	126000
40	18'-0"	45300	4'-6"	16 2	6'-3"	10 0	7 5	6 5	4 84	6 5	4 32	83 7	1.48	1 1	1 1	2 57	2240	43300
100	"	71000	"	"	"	11 0	8 36	7 25	5 5	7 25	5 0	95 5	2 03	1 5	1 5	3 6	3280	64800
125	"	80000	"	"	"	11 0	8 36	7 25	5 5	7 25	5 0	95 5	2 30	1 68	1 68	4 05	3600	76400
150	"	89000	"	"	"	11 0	8 36	7 25	5 5	7 25	5 0	95 5	2 56	1 86	1 86	4 5	3940	85100
200	"	108000	"	"	"	11 5	8 8	7 5	5 72	7 5	5 22	99 4	2 36	2 18	2 18	5 2	4250	103800
250	"	130600	"	"	"	13 5	10 12	8 5	6 6	8 5	6 1	112 7	3 14	2 26	2 26	5 44	5800	124800
300	"	153000	"	"	"	14 0	10 36	9 0	7 00	9 0	6 54	118 7	3 48	2 46	2 46	6 12	6560	146400
40	20'-6"	53000	4'-6"	16 0	6'-6"	11 25	8 58	7 0	5 28	7 0	4 78	92 5	1 68	1 23	1 23	2 75	2740	50300
100	"	80000	"	"	"	12 0	9 24	7 5	5 72	7 5	5 22	100 0	2 34	1 71	1 71	3 85	3850	76100
125	"	90000	"	"	"	12 0	9 24	7 5	5 72	7 5	5 22	100 0	2 62	1 92	1 92	4 35	4250	85700
150	"	100000	"	"	"	12 0	9 24	7 5	5 72	7 5	5 22	100 0	2 93	2 13	2 13	4 82	4650	95300
200	"	124000	"	"	"	12 5	9 66	8 0	6 18	8 0	5 66	106 0	3 36	2 44	2 44	5 75	5500	118500
250	"	147000	"	"	"	14 0	10 36	9 0	7 04	9 0	6 54	118 6	3 89	2 51	2 51	6 32	6600	140800
300	"	170000	"	"	"	15 0	11 44	9 5	7 40	9 5	6 98	126 2	3 60	2 7	2 7	6 6	7600	162400
40	21'-0"	60000	4'-9"	17 7	6'-10	11 5	8 8	7 25	5 5	7 25	5 0	95 0	1 92	1 42	1 4	3 19	3080	56900
100	"	91600	"	"	"	12 5	9 66	8 0	6 16	8 0	5 66	106 0	2 53	1 88	1 88	4 4	4350	86600
125	"	102000	"	"	"	12 5	9 66	8 0	6 16	8 0	5 66	106 0	2 91	2 1	2 1	4 95	4800	97200
150	"	113000	"	"	"	12 5	9 66	8 0	6 16	8 0	5 66	106 0	3 22	2 32	2 32	5 49	5250	107700
200	"	138000	"	"	"	13 5	10 12	8 5	6 6	8 5	6 0	112 0	3 86	2 65	2 65	6 36	6350	131600
250	"	164000	"	"	"	15 0	11 44	9 5	7 18	9 5	7 0	126 0	4 31	2 79	2 79	6 8	7500	153500
300	"	191000	"	"	"	16 0	12 32	10 0	7 92	10 0	7 42	132 8	4 25	3 0	3 0	7 22	8650	182300
40	22'-0"	67800	5'-0"	19 0	7'-3"	12 0	9 24	7 5	5 72	7 5	5 22	100 0	2 14	1 6	1 6	3 38	3600	64200
100	"	103000	"	"	"	13 5	10 12	8 5	6 6	8 5	6 1	113 7	2 66	2 06	2 06	5 0	4900	98100
125	"	115000	"	"	"	13 5	10 12	8 5	6 6	8 5	6 1	113 7	3 13	2 3	2 3	5 56	5360	109600
150	"	127000	"	"	"	13 5	10 12	8 5	6 6	8 5	6 1	113 7	3 52	2 54	2 54	6 15	5850	121100
200	"	154000	"	"	"	14 0	10 56	9 0	6 84	9 0	6 54	118 7	4 0	2 88	2 88	7 15	6900	147100
250	"	186600	"	"	"	16 0	12 32	10 0	7 92	10 0	7 42	133 0	4 35	3 04	3 04	7 42	8300	177700
300	"	220000	"	"	"	17 0	13 2	10 5	8 36	10 5	7 86	140 7	4 7	3 32	3 32	7 95	9300	210500
40	23'-0"	74500	5'-3"	21 2	7'-8"	12 5	9 66	8 0	6 16	8 0	5 66	106 0	2 42	1 78	1 78	4 1	3960	70500
100	"	114500	"	"	"	13 75	10 34	8 75	6 82	8 75	6 32	115 6	3 23	2 32	2 32	5 65	5500	109000
125	"	127500	"	"	"	14 25	10 78	8 75	6 82	8 75	6 32	115 6	3 58	2 59	2 59	6 05	5950	121300
150	"	141000	"	"	"	14 25	10 78	8 75	6 82	8 75	6 32	115 6	3 96	2 86	2 86	6 71	6700	134300
200	"	171000	"	"	"	15 0	11 46	9 5	7 18	9 5	7 0	126 2	4 42	3 15	3 15	n/a	8000	163000
250	"	206000	"	"	"	17 0	13 2	10 5	8 36	10 5	7 86	140 8	4 7	3 26	3 36	7 95	9500	196500
300	"	242000	"	"	"	17 75	13 76	11 0	8 8	11 0	8 3	146 5	5 15	3 66	3 66	8 75	10750	226300
40	24'-0"	64300	5'-6	23 6	8'-0"	13 5	10 12	8 75	6 35	8 25	5 83	109 0	2 71	1 94	1 94	4 65	3600	61300
100	"	126000	"	"	"	14 5	11 0	9 0	7 04	9 0	6 35	113 2	3 38	2 36	2 36	6 1	6400	120000
125	"	141000	"	"	"	15	11 0	9 0	7 04	9 0	6 34	113 2	4 0	2 87	2 87	6 82	8300	134000
150	"	155000	"	"	"	14 5	11 0	9 0	7 04	9 0	6 34	113 2	4 2	3 0	3 0	7 5	10250	147500
200	"	189000	"	"	"	15 5	12 76	10 0	7 92	10 0	7 42	133 6	4 35	3 43	3 43	n/a	9350	180000
250	"	228000	"	"	"	17 5	13 64	11 0	8 8	11 0	8 3	146 6	5 11	3 66	3 66	8 9	10600	217400
300	"	261000	"	"	"	19 0	14 96	11 5	9 24	11 5	8 74	154 0	5 85	4 0	4 0	9 3	12300	248700

to find anything throwing any light upon how the Chicago code was derived, and I am therefore not in a position to say whether my method is the same as was used by the Chicago experts in drafting their by-law, but at any rate the results check, and my method is more or less based along theoretical lines.

In Table No. 1 I have endeavored to furnish information that may be useful for the architect or the engineer in designing this type of construction according to the



NOTE.—The strips are for design purpose only. The reinforcement is arranged as shown in Figure V.

Fig. No. 1.

Chicago code. The dimensions given are those I believe to be the most economical. I have assumed that the concrete is stressed up to 700 lbs. per square inch and that the steel is stressed up to 18,000 lbs. per square inch, and due to the very satisfactory tests this department has conducted, I am prepared to allow these stresses in the future for this method of design. This table may be used for what is known as the four-way system. The two-way system will probably require the table to be considerably modified.

Chicago By-law for Flat Slabs.—This discussion refers to what is known as the four-way type of construction.

W = total panel load (live and dead) = wL^2 for square panel.

L = span in feet.

B = width of direct band = $\frac{L}{2}$. D = width of centre band = $\frac{L}{2}$.

Referring to Fig. No. 1 it will be noticed that the bending moment for the side strips half-way between the column centres is $Mb = \frac{WL}{80}$ (resisted by one direct band) - - - - - - - - - - - - - (a)

Bending moment for the centre strip half-way between the column centres is $Md = \frac{WL}{120}$ (resisted by one diagonal band) - - - - - - (b)

Bending moment for the side strips over the column cap is $Mt = -\frac{WL}{30}$ (resisted by one direct and one diagonal band) - - - - - (c)

Bending moment for the centre strip along the column centres is $Ms = -\frac{WL}{120}$ (resisted by top rods) - - - - - - - - - - (d)

For wall panels, the moments are as follows when slab is supported by wall columns. (Moments increased approximately by 20%):—

$Mb.w = \frac{WL}{66}$ resisted by one direct band - - - - - (e)

$Md.w = \frac{WL}{100}$ resisted by one diagonal band - - - - - (f)

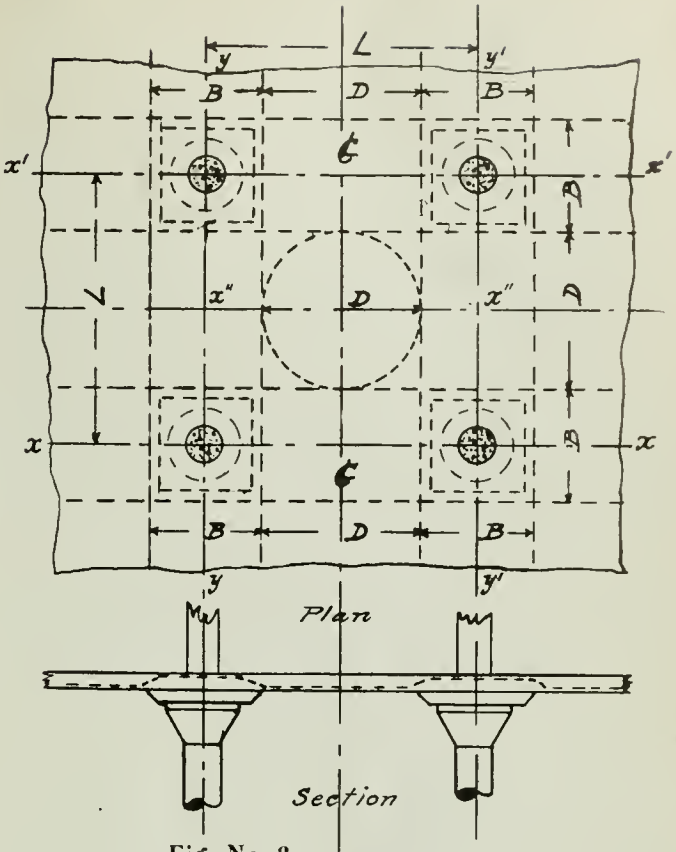


Fig. No. 2.

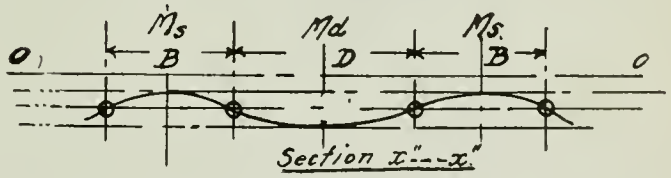


Fig. No. 3.

$M = 112\ bt^2$ when $S = 18{,}000$ and $C = 700$.

$M = \begin{cases} \text{bending moment in inch-lbs.} \\ \text{for } \frac{3}{4}\% \text{ of steel.} \end{cases}$

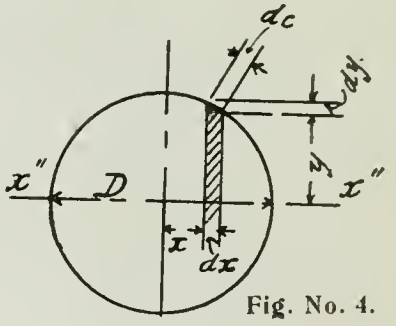


Fig. No. 4.

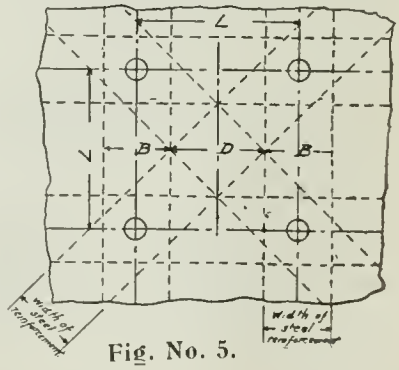


Fig. No. 5.

$M_{t.w} = -\frac{WL}{24}$ resisted by one diagonal band and one direct band - - - (g)

$M_{b.w} = -\frac{WL}{100}$ resisted by top rods - - (h)

For wall panels, the moments are as follows, when slab is supported on brick walls. (Moments increased approximately by 50%):—

$M_{b.w} = \frac{WL}{54}$ resisted by one direct band - (i)

$M_{d.w} = \frac{WL}{80}$ resisted by one diagonal band - (j)

$M_{t.w} = \frac{WL}{20}$ resisted by one diagonal band and one direct band - - - (k)

$M_{t.w} = \frac{WL}{80}$ resisted by top rods - - (l)

For rectangular panels, when the sides do not vary in length more than 50%, the average length may be taken and panels figured as square.

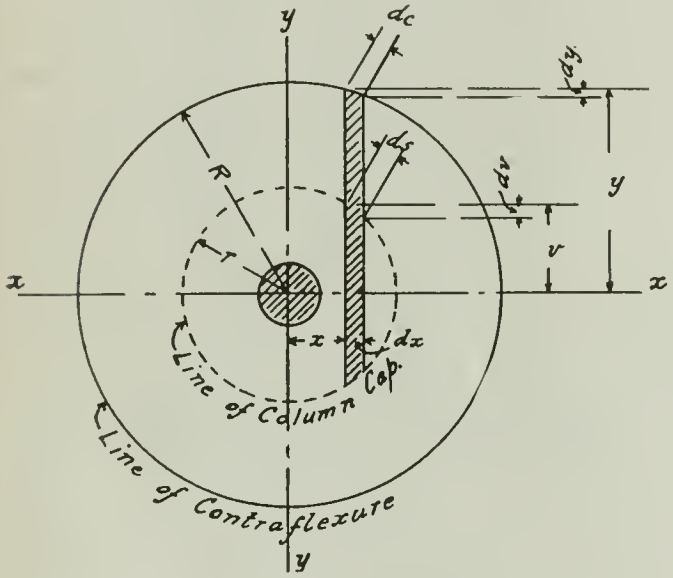


Fig. No. 6.

For the four-way system of reinforcement the amount of steel found for the positive moment of each strip D by designing in this manner shall be that used in the diagonal band. For the positive moment in each strip B, the required amount of steel in the cross-band shall be obtained by multiplying the steel used in the design of the assumed square panel by the cube of the ratio found by dividing the length or breadth of the rectangular panel by the side of the assumed square panel, for the long and short sides of the panel, respectively. The compressive stresses shall be calculated on the basis of a width equal to one-half of the side of the assumed square panel, and on the assumptions used in the calculations of compressive stress in square panels. In no case shall the amount of steel in the short side be less than two-thirds of that required for the long side.

Analysis of Chicago By-law for Flat Slabs.—This discussion refers to what is known as the four-way type of construction.

Referring to Fig. No. 2 and assuming the slab to be cut along $y - y$ and $y' - y'$, making a continuous beam of width L, and to be rigidly fixed at each end, of uniform section and loaded with a uniformly distributed load of w lbs. per square foot (this includes live and dead load) then $W = wL^2$.

Let Mr = bending moment in foot-lbs. at point of support for entire width of slab.

Mc = bending moment in foot-lbs. at centre of panel for entire width of slab.

Then $Mr = -\frac{WL}{12}$ - - - - - - (1)

and $Mc = +\frac{WL}{24}$ - - - - - - (2)

It is evident that the same conditions exist if the plate is cut along $x' - x'$ and $x - x$ and the ends rigidly fixed.

Therefore, equation (1) becomes $Mr = -\frac{WL}{24}$ - - (3)

axis $x' - x'$ and $x - x$,

and equation (2) becomes $Mc = +\frac{WL}{48}$ - - - (4)

axis $x'' - x''$.

Let L = span c. to c. of columns in feet.

B = width of side strips in feet.

D = width of centre panel in feet.

W = total panel load (live and dead) = wL^2 for square panel.

Referring to Fig. No. 2, it is evident that the centre panel D will have a tendency to sag down in the centre, and any section taken through the centre would be bent into a parabola or the centre part would be approximately a parabolic surface of revolution.

If the centre circular part is assumed to be taken out and the bending moment is found (see Fig. 4) we get the following:—

Let w = load per square unit (live and dead) and

w' = load per lineal unit of circumference.

Then $w' = \frac{rw}{2}$ - - - - - - (5)

Then the differential moment of one strip $d.x.$ would be $d(m) = \left(\frac{rw}{2}\right) y.\ dc - \frac{w}{2}\ y^2\ dx$ - - (6)

Substituting for dc and y in terms of x, equation (6) reduces to

$d(m) = \frac{w}{2} x^2\ dx$ - - - - (7)

and $\frac{Md}{2} = \frac{w}{2}\int_0^r x^2\ dx = \frac{w}{2}\frac{r^3}{3} = \frac{wr^3}{6}$

or $Md = \frac{wr^3}{3}$ = bending moment across axis $x'' - x''$ - - - - - (8)

But $r = \frac{D}{2}$,

Therefore, $Md = \frac{wD^3}{24}$ - - - - - (9)

Referring to Fig. No. 5, and the conditions shown, then

$B = .414\,L$ - - - - (10)

$D = .586\,L$ - - - - (11)

$D^3 = .2L^3 = \frac{2}{10} L^3$ - - - (12)

Substitute value found in equation (12) for D^3 in equation (9), then

$Md = +\frac{wL^3}{120}$ - - - - (13)

But $W = wL^2$, substitute in equation (13)

$Md = +\frac{wL}{120}$ - - - - (14)

The bending moment given in equation (14) is resisted by one diagonal band, and it is the same as given by the Chicago by-law. (See equation "b".)

By referring to equation (4) it will be noticed that the total bending moment across axis $x'' - x''$ is $Mc = +\frac{WL}{48}$, and it was just found by equation (14) that the bending moment for the centre panel is $Md = +\frac{WL}{120}$.

Therefore $Mb = Mc - Md = \frac{WL}{48} - \frac{WL}{120} = +\frac{WL}{80}$ (15)

or $Mb = +\frac{WL}{80}$ = bending moment in side panels and is resisted by one side panel B. This is the same as the Chicago by-law. (See equation "a".)

Referring to equation (3).

$$Mr = -\frac{WL}{24}$$

Let w = load per square foot.
p = load per unit length of line of contraflexure.
q = load per unit length of line of column cap.
Mt = bending moment across axis $x - x$. (See Fig. 6.)

Fig. 6 shows the approximate line of contraflexure around column centre. It is not a circle but most authorities assume it to be so.

The approximate bending moment may be found across axis $x - x$ as follows, and is what is given for Mt. See equation (c).

If a differential strip is assumed of a width of dx,

then $dm = p\,dc\,y + w\,y\,dx\frac{y}{2} - q\,ds\,v - w\,v\,dx\frac{v}{2}$ (16)

Substituting the following values and then integrating,

$$y = \sqrt{R^2 - x^2}$$

$$dc = \frac{R\,dx}{y}$$

$$ds = \frac{r\,dx}{v}$$

Then

$$\frac{Mt}{2} = pR\int_0^R dx + \frac{w}{2}R^2\int_0^R dx - \frac{w}{2}\int_0^R x^2\,dx - qr\int_0^r dx - \frac{w}{2}r^2\int_0^r dx + \frac{w}{2}\int_0^r x^2\,dx \quad - \quad (17)$$

$$\frac{Mt}{2} = pR^2 + \frac{w}{2}R^3 - \frac{w}{6}R^3 - qr^2 - \frac{w}{2}r^3 + \frac{w}{6}r^3 \quad (18)$$

Substituting following values in equation (18)

$$p = \frac{wL^2 - w\pi R^2}{2\pi R}$$

$$q = \frac{wL^2 - w\pi r^2}{2\pi r}$$

$$R = \frac{L}{4}$$

$$r = \frac{L}{8} \text{ approximately.}$$

Then equation (18) becomes

$$\frac{Mt}{2} = 57\,wL^3$$

or $Mt = 28.5\,wL^3$ - - - - - (19)

but $W = wL^2$

then $Mt = 28.5\,WL$, resisted by one diagonal band and one straight band - - - - - - - (20)

Referring to equation (c) it will be noticed that the Chicago code gives Mt as $-\frac{WL}{30}$, which is very nearly the same as is given by equation (20).

But $Mr = -\frac{WL}{24}$ = total moment for the full width of the slab along column centres, and taking $Mt = -\frac{WL}{30}$ then $Ms = Mr - Mt$.

Therefore, $Ms = -\frac{WL}{24} + \frac{WL}{30} = -\frac{WL}{120}$ (21)

Ms is resisted by short rods at top of concrete slab.

This is verified by Trelease in his experiments on a rubber slab as he found that

$Ms = Md$ which was found to be $\frac{WL}{120}$. See equation (14.)

Shearing Stresses Allowed by the Chicago Code.—The allowable unit punching shear on the perimeter of the column capital shall be three-fiftieths (3/50) of the ultimate compressive strength of the concrete, as given in section 546 of the building ordinance. The allowable unit shear on the perimeter of the drop panel shall be three-one-hundredths (3/100) of the ultimate compressive strength of the concrete. In computing shearing stress for the purpose of determining the resistance to diagonal tension the method specified by the ordinance shall be used.

Mixture	Ultimate compressive strength per sq. in.
1 cement, 1 sand, 2 broken stone, gravel or slag	2,900
1 cement, 1½ sand, 3 broken stone, gravel or slag	2,400
1 cement, 2 sand, 4 broken stone, gravel or slag	2,000
1 cement, 2½ sand, 5 broken stone, gravel or slag	1,750
1 cement, 3 sand, 7 broken stone, gravel or slag	1,500

MOUNT ROYAL TUNNEL COMPLETED.

Official announcement was made last week by the Canadian Northern Railway that the Mount Royal tunnel is now practically completed, and that a large gang of men are at work in laying the permanent trackage through the tunnel.

Sir Donald Mann is now considering the tenders that have been received for the temporary terminal, costing about $150,000, which will be erected at the corner of Lagauchetiere and St. Monique Streets. Contract will be let almost immediately for the removal of 240,000 cu. yds. from this site, and of this amount 140,000 cu. yds. will be taken through the tunnel as fill for the company's yards at Cartierville.

It was stated by C.N.R. officials last week that regular trains would be running into Montreal by next June. The lighting of the tunnel will be considered later on. Two 80-ton electric locomotives are now in use in the tunnel and four more will be purchased for the regular service.

TORONTO ENGINEERS' CLUB NIGHT.

"Club Night" was observed last evening by the members of the Engineers' Club of Toronto. Informal dinner was served at 7 p.m. to a representative gathering, many members having been attracted by the announcement of a talk on the organization and operation of Toronto's works department by R. C. Harris, commissioner of works.

A GRAPHIC METHOD OF DETERMINING CENTRE OF GRAVITY AND MOMENT OF INERTIA.

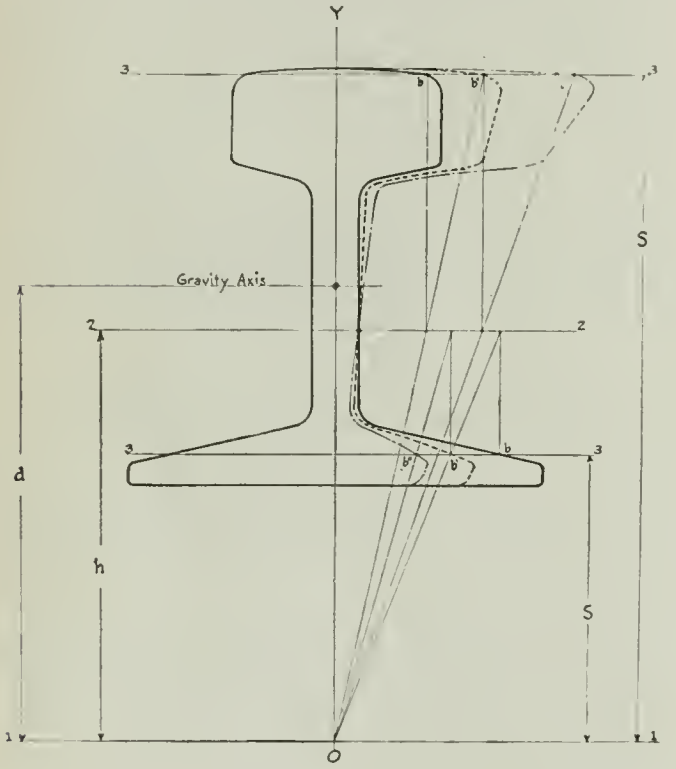
By H. B. Wrigley.

THE centre of gravity and moment of inertia are properties well known for common sections of beams, shafts, etc., but for other sections, as rails, automobile axles, machine frames, crane-hooks, etc., where the outline is such that the integration in the expressions for centre of gravity and moment of inertia is difficult, the following graphic method will be found convenient.

Let it be required to locate an axis passing through the centre of gravity of the rail shown in the figure.

Draw axes 1—1 and 2—2 at a convenient distance h apart, parallel to the required axis.

Draw any line as 3—3 parallel to 2—2 and project the points b—b on 2—2; from O and through the intersections on 2—2 draw straight lines intersecting 3—3 at



b'—b'; continue this process by determining other points b'—b' and connect them to produce a transformed section.

(a) The statical moment, M, of a plane surface with respect to an axis in the plane is equal to the sum of the products of the elementary areas and their distance from the axis considered, or, it is the product of the area of the plane surface and the distance of its centre of gravity from the axis.

Measure the area of the original section and let A denote this area; also let d be the distance from 1—1 to the gravity axis; then by definition $M = Ad$. Measure the area of the transformed section $b'.....b'$ and let A_1 denote this area; then, M, for the original section $= hA_1$, therefore $d = \frac{hA_1}{A}$, which will now be proved.

Let e denote the distance from axis O—Y to b;
e' the distance from axis O—Y to b';
ew an elementary area;
S the distance of ew from axis 1—1.

It will be noticed that $\frac{e}{h} = \frac{e'}{S}$, hence $e = \frac{e'h}{S}$.

By definition (a) $M = ew \cdot S \ldots\ldots\ldots + ew \cdot S$
$= h(e'w \ldots\ldots\ldots + e'w)$
$= hA_1$

but $M = Ad$, therefore $d = \frac{hA_1}{A}$

To determine the moment of inertia of the section with respect to its gravity axis.

Project the points b'—b' on 2—2; from O and through the intersections on 2—2 draw straight lines intersecting 3—3 at b''—b'' and through these points construct a second transformed section.

(b) The moment of inertia I of a plane surface with respect to any axis as 1—1 is the sum of the products obtained by multiplying the area of each element of the surface by the square of its distance from the axis.

(c) The moment of inertia I of a plane surface with respect to any axis as 1—1 is equal to the moment of inertia I with respect to a parallel axis passing through the centre of gravity of the surface plus the product of the area of the surface by the square of the distance between the axes; then $I = I_g + Ad^2$.

Measure the area of the transformed section $b''.....b''$ and let A_2 denote this area, then for the original section $I = h^2 A_2$, therefore $I_g = h^2 A_2 - Ad^2$, the required moment of inertia.

Let e'' denote the distance from axis O—Y to b''. It will be noticed that $\frac{e'}{h} = \frac{e''}{S}$ and $e' = \frac{he''}{S}$; also that $e' = \frac{eS}{h}$ as before; hence $S^2 = \frac{h^2 e''}{e}$

By definition (b) $I = ew \cdot S^2 \ldots\ldots\ldots + ew \cdot S^2$
$= h^2 (e''w \ldots\ldots\ldots + e''w)$
$= h^2 A_2$

ROAD MAP OF ONTARIO IS BEING MADE.

A road map of Old Ontario, that portion of the province south of a line drawn from Renfrew to the apex of the Bruce peninsula, is in course of preparation. When completed it will show all roads together with the location of waterways, railroads, cities, towns, villages and post offices. Improved roads will be shown in colors and fenced and unfenced roads indicated by distinguishing signs. The scale of the original map is two miles to the inch, and when completed it will measure approximately 10 by 20 feet. A map of reduced scale will be issued for general use.

AMERICAN ROAD BUILDERS' ASSOCIATION.

The fourteenth annual convention of the American Road Builders' Association will be held in Mechanics' Building, Huntington Avenue, Boston, Mass., February 5th to 9th, 1917. It has been the custom for six years to hold the convention of the American Road Builders' Association as the American Good Roads Congress. The object of this is to bring together individuals of all classes interested in roads and streets, not only from a technical and scientific standpoint, but from a civic point of view as well. The programme for the convention and congress is now in course of preparation. The secretary is E. L. Powers, 150 Nassau Street, New York.

PORTAGE AVENUE IMPROVEMENT, EDMONTON

DESCRIPTION COVERING THREE YEARS' WORK ON A WESTERN THOROUGHFARE—CONSTRUCTION METHODS.

By C. C. SUTHERLAND, B.A.Sc., A.M.Can.Soc.C.E.,
Roadways Engineer, Edmonton.

DURING 1916 the city of Edmonton completed the improvement of Portage Avenue for the Hudson's Bay Company. This is a notable thoroughfare and a general description covering the three years' work on it will be of interest to readers of *The Canadian Engineer.*

At the time that property known as the Hudson's Bay Reserve was thrown open for sale, the company promised the purchaser that certain improvements, such as grading, paving, plank walk construction, sewer and water, and the extension of electric light and telephone, would be undertaken. The company then entered into an agreement with the city whereby these utilities would be extended at the company's expense, in lieu of the corporation extending its street railway along Portage Avenue.

Portage Avenue is one of the two diagonal roads cutting the reserve. Commencing in the down-town district it leads in a northwesterly direction out towards the Grand Trunk Pacific and the Edmonton-Dunvegan Railway shops. It will also handle considerable of the traffic from the town of St. Albert and Mornville district to the northwest of the city.

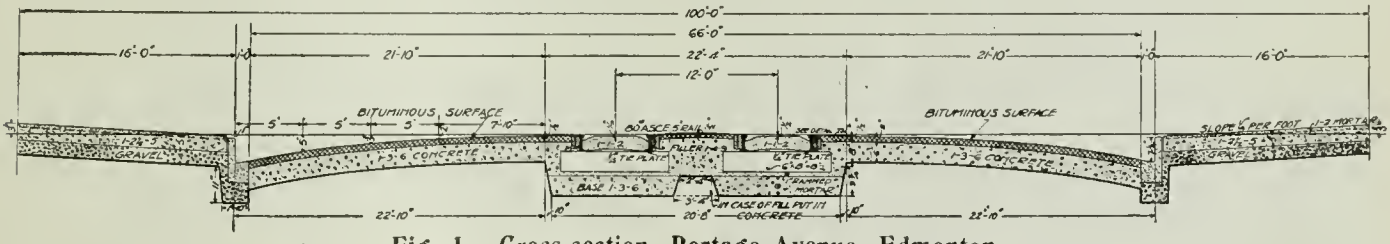


Fig. 1.—Cross-section, Portage Avenue, Edmonton.

The total length of this street is 9,911 lineal feet, with a total width between property lines of 100 lineal feet. This area is covered with 55,609 square yards of regular pavement on a 6-inch concrete base, 24,300 square yards of pavement on the street railway allowance, 249,379 square feet of concrete walk, with 17,444 lineal feet of combined curb and gutter. The total cost of this work was $411,345, of which amount the Hudson's Bay Company took $341,761, and the city $69,584. From the above figures it will be seen that the pavement, including the street railway allowance, has cost the company $3.34 per square yard, or for the completed street at the rate of $34.50 per lineal foot. The concrete walk construction cost $62,361, or at the rate of 24.7 cents per square foot, while the combined curb and gutter cost 75 cents per lineal foot.

In deciding on a cross-section for this avenue, consideration was given to the probable through traffic as a leading road, and also of the traffic ordinarily accommodated on a retail business street. But, as will be seen from the accompanying cross-section (Fig. 1) the wide street allowance between property lines gave ample room for both pedestrian and vehicular traffic.

About midway along the avenue at the point where Kingsway Avenue intersects Portage Avenue, a large area, known as Strathcona Square, was left for road and park purposes. In this district, with a tendency for the growth of the city to the northwest, it was thought that this intersection might well become a very busy one and for that reason the first consideration was given to traffic facilities, to see that all intersecting streets were carried through without obstruction, and that pedestrian traffic was given protection. Fig. 2 shows the adopted design, but at present only that portion covered by Portage Avenue has been constructed.

In providing drainage for this street and all side streets running into it, a storm-water sewer was built under the south roadway and offset from the street railway tracks a distance of 10 feet in order to avoid any possible settlement of the new trench. This sewer is not continuous, but leads into the city system at three points, one at 105th Street, one at 108th Street and the other into the tunnel sewer by a drop manhole at 113th Street. The leads carrying the drainage from the catch-basin silt-well to the manhole at the street intersection are all 8-inch connections.

The catch-basin is made up of the side and top inlet type, the casting resting on a silt-well constructed of three 24-inch vitrified tile pipe culls. Fig. 3 shows in detail this type of construction, which has been in use in this city for the past 10 years, is cheap and easy to construct, and so far has given good satisfaction.

The ground covered by Portage Avenue has a gradual rise from 101st Street to 121st Street, but is somewhat rolling, and two large sloughs are crossed, one at 108th Street, and the other at 115th Street. The knolls on each side of the sloughs were covered with from one to two feet of black loam resting on a heavy clay. Two years previous to the beginning of permanent construction, this street was graded with a roadway 30 feet wide. Contemplating future construction, this roadway was graded with an offset from the centre line sufficient to clear the street railway allowance. This was found to be a great help as material teams and traffic continued to use the old graded roadway during the construction of the street railway tracks.

The total construction from 101st Street to 121st Street was completed in three years, a third each year. The first section of paving and street railway construction

was completed in 1914 by the National Paving Company of Winnipeg, the balance was completed in 1915 and 1916 by the Crown Paving Company of Calgary and Edmonton. The concrete walks constructed on the three sections were built by Messrs. Swanson & Kaline. In carrying out this work, the contractors did their best to make this street one of the finest in the city.

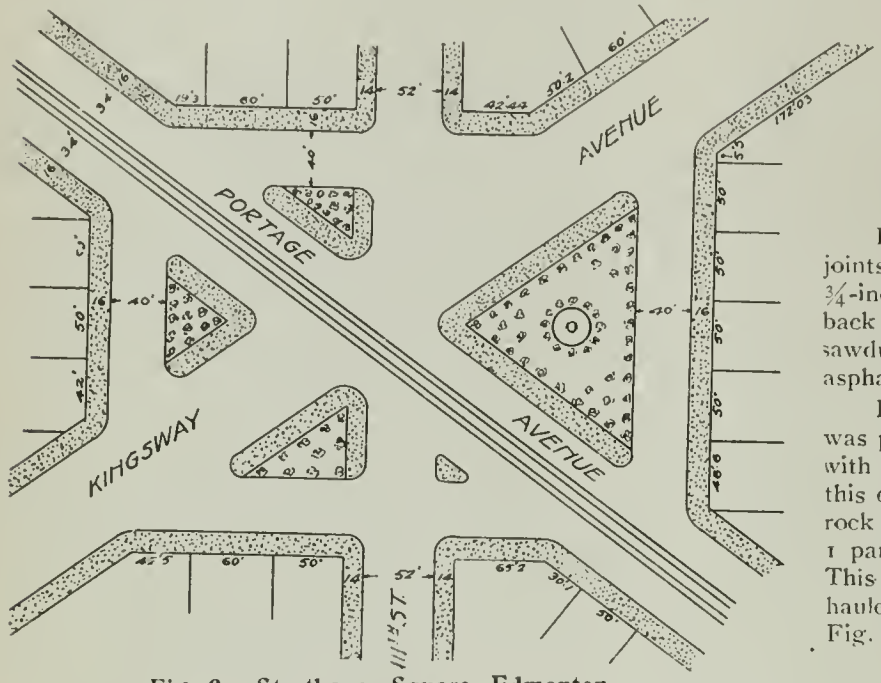


Fig. 2.—Strathcona Square, Edmonton.

In taking out the excavation for the roadway and sidewalks, over 32,000 cubic yards were removed. All of the sidewalk excavation and the roadway excavation of the first section was moved with dump wagons, but the rough grade of the last-two-thirds of the street was moved with wheel scrapers. In crossing the slough, and especially along the edges, a great deal of muskeg ground was found. In such cases all mouldy materials was taken out down to the clay, and the grade allowed to stand until well dried out before refilling. When grading the roadway across the sloughs two years before, corduroy had been laid down before placing the fill. Although the corduroy material was still in condition and one might be inclined to leave it in place under a three-foot fill, yet it was thought advisable to remove all such material and refill.

Fills were made by dumping material in layers of 8 to 10 inches before rolling, but it was often found that after the wheelers had travelled over a lift for some time, that the ten-ton power roller had little or no effect.

The curb and gutter constructed on this street is the combined type, built continuous throughout the block, with thin plate joints every 8 feet and with regular ¾-inch expansion joints each 50 feet. The body of the curb and gutter is made up of concrete mixed in the proportion of 1 part cement, 2 parts sand and 4 parts crushed rock or washed gravel, with limiting size of one inch. The mortar surface is made up in the proportion of 1 part cement to 2 parts sand. On construction done during 1916 a 6-inch gravel cushion was placed under the curb and gutter section to act as a drain, the lower end of each block being joined up to the catch-basin. We have watched these connections during and after a heavy rain and by the large amount of water reaching the silt-well, it is evident this gravel drain has justified its construction.

Concrete walks were constructed on each side of the street. The excavation was taken out and after the subgrade had been rolled with a light power roller, it was covered with 4 inches of gravel to form a cushion. Most of the subsoil in this city is of a heavy clay formation which cracks badly during cold weather and it was to insulate the concrete walk slab from the clay foundation that the practice of laying a gravel cushion was adopted. The concrete slab is made up of a base 4 inches thick and followed immediately with a mortar surface one inch thick. The concrete in the base is mixed in the proportion of 1 part cement to 2½ parts sand and 5 parts clean gravel or crushed rock. The surface is given a rough brush finish.

Expansion is provided by placing ¾-inch joints across the walk every 50 feet, with a ¾-inch joint along the edge of the walk at the back of the curb. The joints are partly filled with sawdust, the top being sealed with a light grade asphalt.

In constructing the roadway the subgrade was prepared in the usual way, and then covered with a concrete base six inches thick. In mixing this concrete base only washed gravel or crushed rock was used, and mixed in the proportion of 1 part cement to 3 parts sand to 6 parts stone. This material was mixed in a batch mixer, and hauled to the street in horse carts, as shown in Fig. 4. The surface was then struck with a tem-

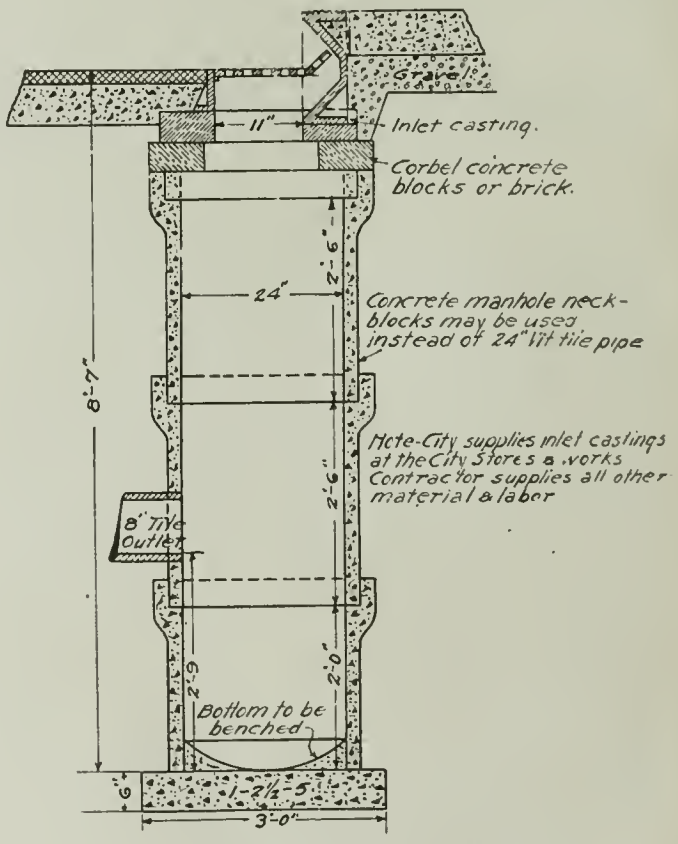


Fig. 3.—Detail of Catch Basin.

plate resting on the gutter at one end and on a grade board at the other end. The surface of the base was left rather smooth. After the base had set sufficiently to safely carry the roller, a 2-inch asphaltic concrete surface

was laid. On the first section, between 101st Street and 106th Street, the mineral aggregate has a rather coarse grading, while the mineral aggregate of the remaining two sections laid by the Crown Paving Company is a fine grade mixture.

In checking the quality of material used on the work, samples of cement were tested from each car and the

Fig. 4.—Concrete Being Hauled to Job in Carts.

material held pending the seven-day test. In addition to cement tests and a general inspection of all materials used, a rather extensive series of tests were carried out on cylinders of concrete taken from the work each day. After allowing to set up in water for a period of 28 days, the samples were taken to the University of Alberta for testing. It must he admitted that the results were not satisfactory. The difference in temperature from spring through summer to fall, together with what one might call the personal equation of the inspector taking the samples in the cylinders, all combined to make the results so erratic as to be of little value except as a rough check. It might be that if one man took all the samples, and cured them in a constant temperature, the results would be more uniform.

In constructing the double track in the street railway allowance, our standard section for 12-foot centres was used. After the subgrade had been prepared a 6-inch concrete base, made up in the proportion of 1 part cement

Fig. 5.—With Track to Grade, Filler is Poured up to Bottom of Proposed Pavement.

to 3 parts sand to 6 parts washed gravel or crushed rock, was laid. As soon as this hase had sufficiently set the skeleton track was assembled, spiked and bonded. In bringing the track to grade and alignment, wooden shims were used, but care was taken to keep them well out at the ends of the ties in order that the mortar from the filler would work under the ties and form a good bearing directly beneath the rail. With the track to grade, as partly shown in Fig. 5, the filler is poured up to the bottom of the proposed pavement. Fig. 6 shows the method of pouring filler on two tracks at once.

The rails used in the track work were 5-inch 80 lbs. A.S.C.E. section, and in making joints at the rail lengths, continuous joint plates were used. Care was taken to see that a tie was placed under each end of the joint. On a part of this year's work we ran out of continuous joints, and in looking for a substitute we adopted a 34-inch angle splice bar with six holes. Under this joint we placed three ties, one at each end with one directly under the joint. On top of the ties at each joint and for three ties on each side were placed ¼-inch tie plates. We have found the joints to be a weak point in track construction, and for that reason are paying special attention to them.

In paving between the gauge lines, two methods were used. On the first section, between 101st Street and 106th Street, grooved sand stone block sets were laid along the rail and the space between laid with a two-inch asphaltic concrete surfacing. On the remaining two sections a rich concrete slab of 1 : 1 : 2 mixture and four inches thick was laid between the gauge lines. On the outside of each rail a double row of treated wood blocks was laid, the space under the ball filled with a treated wood filler strip. In setting the wood blocks a mortar bed was first laid on top of the concrete filler, and after allowing sufficient time to

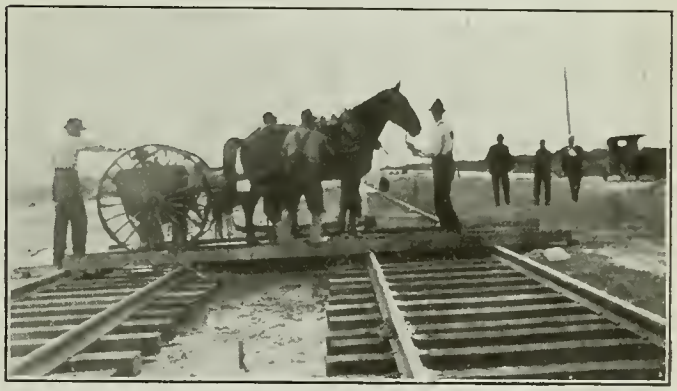


Fig. 6.—Shows Method of Pouring Fill on Two Tracks at Once.

set, was painted with a ¼-inch coat of hot asphalt and followed immediately with the wood blocks. The same result may be obtained by dipping each block in a pail of hot asphalt before laying on the mortar bed. On the last section of the work the inside of the rail was painted with an asphaltic paint before the concrete slab was poured, the idea being to prevent the concrete from bonding to the rail. It is recognized that a rail laid on wooden ties will move up and down, as it should do to give a certain amount of resilience to the track, and in order to provide for this movement without affecting the adjoining pavement, the asphaltic joint on the inside, with the wood blocks on the outside, were introduced.

This work was started under City Engineer A. J. Latornell, now captain in the 75th Battery, with Mr. A. W. Haddow in direct charge, and completed by Mr. A. W. Haddow, now acting city engineer.

Large contracts for lumber, aggregating 16,500,000 feet, exclusive of an open order for all the clear spruce available, have been placed by the Imperial Government with British Columbia mills.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

(Continued from page 48.)

Sewage Disposal and Sanitation (A. Surveyer, chairman), Steel Bridge Specifications (P. B. Motley, chairman), Conservation (James White, chairman), Electro-Technical Commission (L. A. Herdt, chairman), Reinforced Concrete (W. J. Francis, chairman), General Clauses for Specifications (H. Holgate, chairman), Roads and Pavements (W. A. McLean, chairman), and Steam Boiler Specifications (L. M. Arkley, chairman).

The awards of the Gzowski medal and of prizes for the best students' papers will be announced during the annual meeting. As no papers have been presented on mining or metallurgical subjects during the year, there will be no award of medals in these subjects.

A provincial division has been duly constituted under the provisions of By-law No. 56 in the district of Alberta, thus establishing the second provincial division within the society.

The membership of the branches at the date of the last annual meeting was as follows:—

	Corporate.	Non-Corporate.	Total.
Quebec	73	26	99
Ottawa	166	56	222
*Kingston	14	13	27
Toronto	134	83	217
Manitoba	107	37	144
Calgary	43	9	52
*Vancouver	112	20	132
Victoria	54	10	64
Edmonton	33	9	42
Regina	21	2	23
	757	265	1,022

*As reported for 1915.

Under the provisions of an act of the Quebec Legislature, members residing within the province have been exempted from service as jurors.

A very considerable amount of time was occupied during the year in council meetings and by specially appointed committees in connection with the question of the employment of alien engineers by the government. A general statement as to the position of this matter was recently communicated to the membership. It is still under advisement, and such further progress as may be made will be reported from time to time.

A circular letter has been addressed to branches, pointing out that the interests of the profession in Canada will be served by giving attention to engineering matters of importance in the locality of the branch. The Calgary branch rendered a very important service to the city in the early portion of this year by reporting on the construction of a bridge over the Bow River, in regard to the stability of which there was contention. This report completely exonerated the city engineer from the aspersions cast upon him by an alderman, and the action of the branch met with the approval of the board of control and the citizens generally.

In Montreal the local members of the council, during the autumn of 1915, made representations to the city's board of control as to the advisability of going forward with the aqueduct power project. No action having been taken by the city authorities, a number of rate-paying engineers, acting independently of the society, made further representation, and on the invitation of the city authorities made an exhaustive study of the project and have presented a report which completely sustains the position taken by council of the society.

The Quebec bridge excursion, in which the membership was invited to participate, was attended by upwards of 160 members of the society and their friends.

In accordance with the instructions of the last annual meeting the council at an early date in 1916, took measures to constitute the committee on society affairs. Its election was completed on April 18th, and the committee named as its chairman Prof. H. E. T. Haultain on May 16th. A progress report of this committee has been prepared, of which the following is a summary:—

Committee on Society Affairs.—A progress report was issued on November 20th by the committee on society affairs, of which Prof. H. E. T. Haultain is chairman and E. W. Oliver secretary.

A number of recommendations made to the committee by various members were transmitted to the membership for the latter's consideration. The committee found diversity of opinion on several important points, and stated that some of the features of the situation called for further deliberation before final opinion could be expressed. Several sub-committees are still at work.

Among the recommendations submitted to the membership, it is interesting to note a proposed change of name from "Canadian Society of Civil Engineers" to "Canadian Institute of Civil Engineers" as suggested by Mr. Geo. Mountain at the last annual meeting. It is advised that the entire by-laws be redrafted. Systematic publicity in the public press is recommended, and also a systematic effort to have recognized university engineering professors identified with the society so as to secure the co-operation of the universities.

The nominating committee and councillors should be elected by districts, stated the progress committee, and efforts should be made to obtain annual grants from the provincial and Dominion governments.

It is proposed to create a new classification in membership, to be known as "retired members," for which the annual fee will be nominal, for those members over 65 years of age who have been corporate members of the society for over 20 years and who desire to be so classified.

The council may be relieved of some of its duties by the appointment of a "public service committee" to look after public questions and legislation which may appear to be contrary to sound engineering practice or to the interests of the members.

Treasurer's Report.—From a financial standpoint, as also otherwise, the year 1916 was successful, the auditor's statement showing a balance of $3,642, being excess of receipts over expenditure.

The total expenditure was $20,084, while the total receipts were $23,726. The bulk of the receipts, of course, was from fees collected, and it is interesting to note that $2,485 was collected on entrance fees, and especially that $6,512 was collected of fees in arrears—an accomplishment upon which the officials of the society are to be congratulated.

The assets total $113,998, which includes $10,775 cash on hand, $5,000 arrears of fees (estimated value), and $180 debentures. The society's property, house, furniture and books are valued at $97,804.

The only liabilities of any very considerable amount are accounts payable $5,409, rebates due to branches $1,659, and mortgage on property $20,000.

Library and House Committee.—Purchases during 1916 were not made in excess of money presented to the library. Only seven books were purchased, but ten were presented to the society by members and forty-three by non-members. Six additional exchanges were effected, making ninety-seven papers received regularly by the regulations relating to the emploment of engineers by governments, states and cities is being compiled. government, states and cities is being compiled.

Committee on Steel Bridge Specifications.—This committee had twenty meetings during the year, which were attended by most of the Montreal members, the other members having participated by post.

A draft specification was prepared and sent out to the branches for discussion, and it is recommended that this discussion be continued during 1917. Views of all interested authorities are desired so as to have the specification take such form that it will be possible for provincial, municipal and other bodies to adopt it. In the meantime it is proposed that the committee continue its work, including the preparation of a specification for movable bridges, and the revision, where necessary, of the present railway bridge specification. It is suggested by the members of the committee that the committee should go out of office automatically every two years, and that its personnel be chosen as follows: One representative from each of the branches and four members residing at or near headquarters. This arrangement would have the effect of providing at all times a working committee, which would prepare details for discussion for the committee as a whole.

While movable bridges were not included in the preliminary drafts of the highway bridge specification, and were not included in the railway bridge specifications that have been issued, the committee gave consideration to this feature, feeling it to be necessary for complete specifications.

The committee suggests that a mechanical and electrical engineer, conversant with movable bridge practice, would be of great service in this connection, and suggested that the new committee be empowered to add to its number or to consult such experts as may be necessary to draft a complete specification.

International Electro-Technical Commission.—This committee reports that during the year 1916 the work of the commission, as in 1915, was more or less restricted, due, of course, to the war, which must of necessity materially affect all international bodies.

In June, however, the committee had the pleasure of a visit from Mr. C. Le Maistre, of London, England, the general secretary of the commission, the members meeting in Ottawa and discussing with Mr. Le Maistre various matters relating to the commission's present and future activities. At that meeting Mr. Le Maistre stated that while matters naturally could not go ahead in just the same way as formerly, still everything possible was being done by the central office and the various subcommittees to put things in shape so that material progress can be made shortly after conditions return to normal.

Nothing has, of course, been done during the past year towards the holding of any further congresses. Presumably the 1917 meeting, originally scheduled to be held in Petrograd, will be postponed.

Prof. L. W. Gill, the member of the Canadian committee who is at the front, continues to command a battery somewhere in France.

With the exception of Mr. W. A. Duff, of Winnipeg, who resigned during the year, the committee remains as before.

Conservation Committee.—The advance of conservation, of general industrial improvement, in Canada has been impelled and facilitated during the past year by the most powerful stimulus. Progress toward the better utilization of the resources of the Dominion has naturally attained greater momentum in the form of a national necessity than it could be expected to achieve as an inadequately realized desirability, awaiting the creation and support of effective public sentiment. The events of 1916, and especially of the past few weeks, have served to emphasize more forcibly than ever the relation of economic efficiency to national strength and safety.

As a result of recent action the future economic development of the Dominion will benefit by the aid and guidance of systematic industrial research. The appointment of the Industrial Research Commission by the Dominion government and the corporate enterprise of the Canadian Pacific Railway in promoting scientific research will enable Canadian industry to utilize the services of two highly organized institutions. In the same manner as the forest industries are now in receipt of the services of the Forest Products Laboratories at Montreal, every form of industry should be enabled to avail itself of expert assistance in the solution of its peculiar problems. To achieve the maximum results industrial research must be linked up with a thorough system of technical education.

Town planning progress merits special mention as a conservation movement. Aside from its bearing on public health, town planning seeks the economical use of public funds. During the opening decade of the century Canada invested approximately $600,000,000 on municipal growth, largely for civic improvements. Heavy additional expenditures have been made since 1910. The efficient investment of capital on such a large scale cannot be secured as long as municipal development continues in haphazard manner. Adequate legislation and administrative machinery must be provided to control and guide urban expansion. During the past year distinct progress has been made in this diection and it is hoped that every province in the Dominion will shortly possess proper provision for thorough control of housing and town planning.

In practically every branch of primary production and natural resources the war has created special conditions and conservation problems. In many instances the national waste due to failure to utilize our opportunities to the full extent has been greatly reduced. This applies particularly to water powers, the development of which is proceeding rapidly. Similarly, with regard to mining, renewed activity in both basic and subsdiary undertakings has taken place and thorough study of the status of our mineral industries has been undertaken.

It is gratifying to record the decision of the Ontario government to remodel its forest protective service along the most approved lines. The remarkable development of our pulp industry indicates the potential value of our forests and the wisdom of affording the most efficient protection obtainable. The work of determining the extent of our timber resources progresses steadily, surveys of British Columbia and Saskatchewan forests have been completed during the past year.

Committee on Roads and Pavements.—This committee has presented a full report of the year's work, together with proposed standard specifications for crushed stone, gravel, sand and asphaltic road oils. For abstract of the committee's report see page 64.

ARCHITECTURE AND THE GRAND STAND.

By C. V. Johnson, A.M.Can.Soc.C.E.

JUDGING from the examples of grand stands which have more or less recently made their appearance on this continent, particularly with reference to the fireproof structures, it would appear that the co-operation between architect and engineer is not all that it should be, and as far as this particular type of building is concerned the engineer has apparently had things pretty much his own way, with the result that the country has been presented with many structures designed principally with a view to space and public safety rather than aesthetic beauty. This is indeed unfortunate, as the grand stand is essentially an item of considerable importance in the general scheme of any exhibition ground or public place of amusement, and as such may be made to harmonize with the surrounding buildings without detracting from its usefulness and "factor of safety." It is perhaps a debatable question whether the grand stand belongs in the province of the engineer or the architect, but in any case it would appear that a greater "rapprochement" between the two would have a decidedly improving influence on the general result.

Fig. 1.—Facade.

The writer is unable to say whether the numerous concrete structures of this kind, which have been erected in nearly all parts of Canada and the United States, are due to engineers or architects, but judging from their fine air of stability and remarkable unanimity in lack of beauty, would incline to the opinion that the trained eye of the successful architect has had little or nothing to do with the design. This may appear flattering to the architect and the reverse to the engineer, but it will be apparent to the unprejudiced observer that, taking into consideration the different training of the two professions, it is not unnatural. There does not seem to be much room for doubt that the average engineer of to-day, when called upon to design a structure of a certain capacity and given load, human or otherwise, does not concern himself primarily with the superficial beauty of it. It is just on this point where many of us fail to realize our fallibility. In such a case it would appear to be the part of wisdom to turn the job over to a competent architect for a superficial plan, and then proceed to prepare the main supporting body in accordance with the best engineering practice. In following this course the engineer is not laying himself open to criticism, as an engineer is not supposed to be an artist, nor does his training as a rule include a course in architecture, however much it might be desirable. Experience has shown that an architect will, when he finds himself confronted with an engineering problem with the solution of which he is not familiar, call in an engineer to solve it for him. This is certainly not to his discredit; in fact rather the contrary, as although architecture and engineering are very closely allied, they are two distinct professions. This being the case, does it not seem natural that an engineer, when called upon to design a structure, should call in an architect to assist him with the finer points of appearance with which his own training has not familiarized him? In these days of steel and concrete, when the plasticity of the latter can be advantageously used to an unlimited extent, it is a great pity to see massive and extremely ugly structures, some of which have the general appearance of up-ended platforms with windows stuck in them at regular intervals. Not the least of these monstrosities is the average modern fireproof grand stand, and it is time to wake up to the fact that they can, and should, be made with some idea of architectural effect—especially in view of the fact that such a course would entail little or no greater expense.

In this connection it is refreshing to note that a signal departure has been made from the pre-conceived ideas of grand stand design, in the erection of the building now under way for the Provincial Exhibition Commission of Quebec. This structure is unique in design and reflects great credit on the architect for the many fine points of superiority over previous designs for similar structures. It is unfortunate that the work is not as yet sufficiently advanced to illustrate the full beauty of the facade but nevertheless the accompanying illustration (Fig. 1) will give a fair idea of what it will be when completed.

The structure is primarily Doric in design, although radical departures have been made by the architect in his details, these reflecting an originality for which he is justly noted. The facade itself with its columns and arches is one which, while originating in part with the early Dorian idea of column supports, is nevertheless somewhat cosmopolitan, while retaining a symmetry of effect very pleasing and unstilted to the eye.

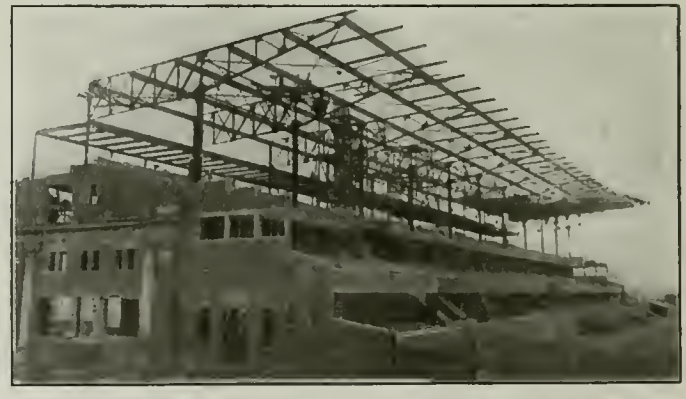


Fig. 2.—Front View, Illustrating Galleries.

Another notable departure conceived and carried out is the series of galleries for the accommodation of the public (Fig. 2). These galleries consist of three tiers, one above the other, constructed on the cantilever plan, thus obtaining the maximum of seating capacity and shelter, under a minimum of roof cover. This system is

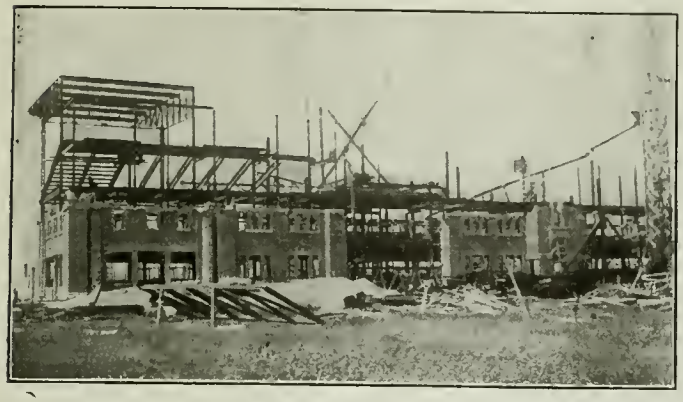


Fig. 3.—Seven Weeks Prior to Exhibition Time.

unique in Canada and the United States, although there is one such in France but having only two tiers of galleries.

The structure, which is 365 feet long over all, has a seating capacity of 6,340 persons, and a standing room accommodation for probably 1,000 additional. In addition to this the interior, which is very spacious and contains three stories, will consist of offices for the various departments, a theatre, restaurants, kitchens, galleries, promenades, etc.

The building is of fireproof construction throughout, resting on concrete foundations, with steel-framed superstructure, brick exterior walls, and terra-cotta interior partitions finished in plaster. The ornamental work, such as columns, cornices, lintels, sills, etc., is principally artificial stone, or, in other words, fine concrete, although in the upper story some of the smaller columns, railings, etc., are of ornamental iron construction. The interior floors are of concrete throughout, the upper ones being reinforced with rib metal, and the whole with a cement top finish. The outside galleries are also of concrete,

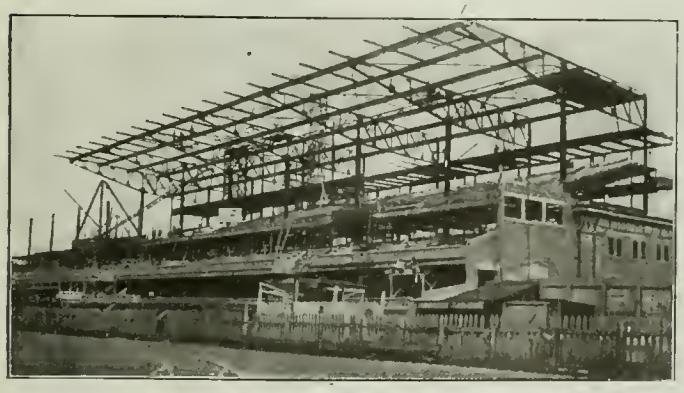


Fig. 4.—One Month Prior to Exhibition Time.

laid on corrugated metal, which is arched between supporting beams of steel. The stairs leading to the galleries and those of the interior, are of unit concrete construction, each step having been moulded separately and laid in cement mortar on steel channel stringers.

The whole building, which will be completed for the coming Exhibition in August, is one of which the city of Quebec may be justly proud; and the architect, Mr. G. Emile Tanguay, senior member of the firm of Tanguay & Lebon, deserves great praise for conceiving and carrying out a scheme which bids fair to revolutionize the design of such structures on this continent.

The general contract for this work was awarded to, and carried out by, the firm of Joseph Gosselin, of Quebec and Levis, and the sub-trades were supplied and erected by the following Quebec firms: Ornamental ironwork, L. H. Gaudry & Co., Limited; plumbing, Fortunat Gingras; wiring and lighting, Goulet and Belanger; roofing and sheet metal work, Eugene Falardeau; and structural steel, the Eastern Canada Steel & Iron Works.

The concrete work was almost entirely placed by means of the Insley spouting method, which was found to be very efficacious in the various stages of the work.

For the accompanying illustrations the writer is indebted to Mr. G. H. Lovett, inspector for the Exhibition Commission, and Mr. H. E. Balfour, assistant engineer for the general contractor. The photograph illustrated in Fig. 3 was taken July 8th, and Fig. 4 July 28th, from which it is interesting to note the progress of construction, and the fact that all three tiers of seats were completed and ready for the accommodation of the public on the 20th of the following month, together with the walls, stairs, etc.

ANNUAL MEETING OF CANADIAN MINING INSTITUTE.

The annual meeting of the Canadian Mining Institute is to be held in Montreal March 7th, 8th and 9th next.

Among the papers either definitely or tentatively promised are the following: "Industrial Preparedness," by Mr. Arthur D. Little; "A Plea for the Union of Capital and Labor," by Hon. Col. David Carnegie; "The Future of the Coal Trade of the Empire," by Mr. Allan Greenwell; "Zinc Electrolysis," by Mr. E. P. Mathewson; "Flotation Processes in the Treatment of Tailings in the Cobalt District," by Mr. John M. Callow; "Sodium Sulphide Precipitation of Silver at the Nipissing Mine, Cobalt," by Mr. R. B. Watson; "Mining and Metallurgical Practice in the Porcupine District," by Mr. A. R. Globe; "Metallurgical Practice at the McIntyre Mine, Porcupine," by Mr. A. Dorfman; "Countercurrent Decantation," by Mr. L. B. Eames; "The Concentration of Molybdenite," by Mr. H. H. Claudet; "The Utilization of Canadian Molybdenite," by Mr. J. W. Evans; "Methods of Mining at the Magpie Iron Mine," by Mr. A. Hassellring; and "Notes on Potash," by Mr. C. W. Drury.

During the first half of 1916 the output of the French coal mines totalled 10,600,000 tons, as against 9,700,000 tons during the first half of the previous year.

The national forests of the United States yielded the Republic a revenue of $2,481,469 in 1915, as compared with $2,437,710 in 1914, $2,467,590 in 1913, $2,157,356 in 1912, $2,026,906 in 1911, and $2,090,148 in 1910.

Whilst copper extraction in Greenland has been left in abeyance, not for want of ore, but on account of the high freights and high prices for fuel, the graphite production is increasing and the work being extended. The deposits are large and the percentage of graphite greater than in most other deposits outside Ceylon. American machinery has been installed and the manufacture of crucibles will be taken up in earnest.

ROAD CONSTRUCTION AT CAMP BORDEN.

By R. T. Bell.

THERE has been laid to date at Camp Borden approximately eight miles of concrete and asphalt macadam roadway. Hughes Avenue, the main thoroughfare, is built of concrete, and extends from the ordnance buildings at the north end of the camp to the Y.M.C.A. building, with side roads to Logie Avenue and the hospital. This road is 22 feet wide; 18 feet of concrete and a 2-foot shoulder of crushed stone on either side. A crown of 2 inches was allowed on this roadway, the concrete at the centre being 8 inches deep. Logie Avenue is of asphalt macadam as is also the loop to the station. This road is 20 feet wide and was built in two courses, the base being 4 inches of 2-inch crushed limestone and the top dressing 2 inches of ½-inch limestone with an asphalt binder.

Section of Concrete Road Completed.

The conditions to which the concrete roads were subjected is unique in the history of concrete road construction. They were thrown open to traffic but three days after being laid and up to the time of writing this article not a crack had appeared. Only in one place did a failure occur; this at the junction of two sections and was due to carelessness in mixing, the proper amount of cement having been omitted in a couple of batches, during the night shift.

The concrete gangs were run night and day as the existing sand roads were rapidly becoming impassable owing to the enormous amount of traffic, and it was an urgent necessity to complete these to assist transportation and to allay the dust nuisance, the old roads being a foot deep in dust. As much as one thousand feet of road was laid in the two shifts. A one-half yard Austin cube mixer was used with caterpillar traction, the materials being delivered to the mixer by teams on a planked sub-grade. A 1:1½:3 mix was used, the material used being pit-run gravel to which was added sufficient 2-inch crushed limestone to bring this to the required proportions. Joints were placed 30 feet apart, the joint material being ¾-in. by 8-in. asphalt. These were placed on an angle with an average deflection of two feet, thus making each slab a keystone. This prevented any abrupt jar being felt at the joint, as no two wheels of any vehicle would be crossing at one time. It also gave the slab a chance of lateral movement in event of heaving or settlement of the sub-grade, which it would not have were the joints at right angles to the road. This style of joint is used in the state of New Jersey and has proved very satisfactory.

In grading the road, great care had to be taken to set the grades to eliminate fills as much as possible, as no time could be allowed for settlement. In any case where a fill did occur it was thoroughly wetted down as made. The grading was done with a Keystone traction digger, the skimmer scoop being used. The daily average was 500 feet.

The material encountered was sand and in no case did quicksand or clay occur. The drainage was excellent and there is little fear of raised slabs through heaving on account of a wet subgrade.

The excavating shovel was followed by a gang of from six to ten men fine grading, the subgrade being planked directly behind them. This plank was teamed ahead as the mixer advanced.

The mixing gang varied considerably on account of the difficulty of getting labor, the intense heat making it almost impossible to hold men.

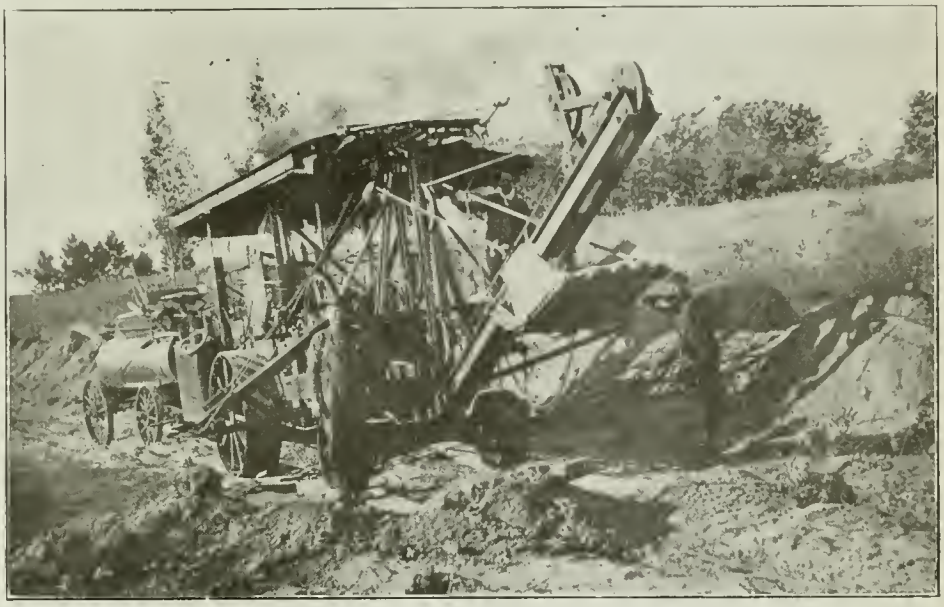
Concrete Mixer.

Owing to the shortage of water on account of the immense consumption during the hot spell it was impossible to keep the concrete wetted down and the seasoning was only of a very perfunctory kind.

A census was taken of the traffic on Hughes Avenue which showed an average of 108 vehicles per hour, this traffic being of a very heavy kind, such as motor trucks, commissariat wagons, etc.

After the road had been in use for about a month all joints were gone over with a wire brush and wherever needed filled with asphalt.

Knowing how this road has stood after being subjected to most trying conditions, the writer begins to have some doubt as to the advisability or necessity of the various costly and slow processes which are sometimes used in the construction of cement roads. Theoretically this road should have gone to pieces long ago, but it shows no sign of doing so as yet.



Keystone Tractor Shovel Used for Grading All Camp Borden Roads.

MANITOBA BRANCH.

The Manitoba Branch of the Canadian Society of Civil Engineers held a regular meeting on January 4th. Prof. E. Brydone-Jack delivered an address on "The Relation of the Society to Scientific and Industrial Research." He referred to the absolute need for organized effort in research and investigation, emphasized by the war. He gave the history and details of organization of the British Committee on Scientific and Industrial Research, followed by that of the Canadian committee, which is being formed along lines similar to the British committee, and also of the committee appointed by the university faculty, all indicating the development of public sentiment along this line.

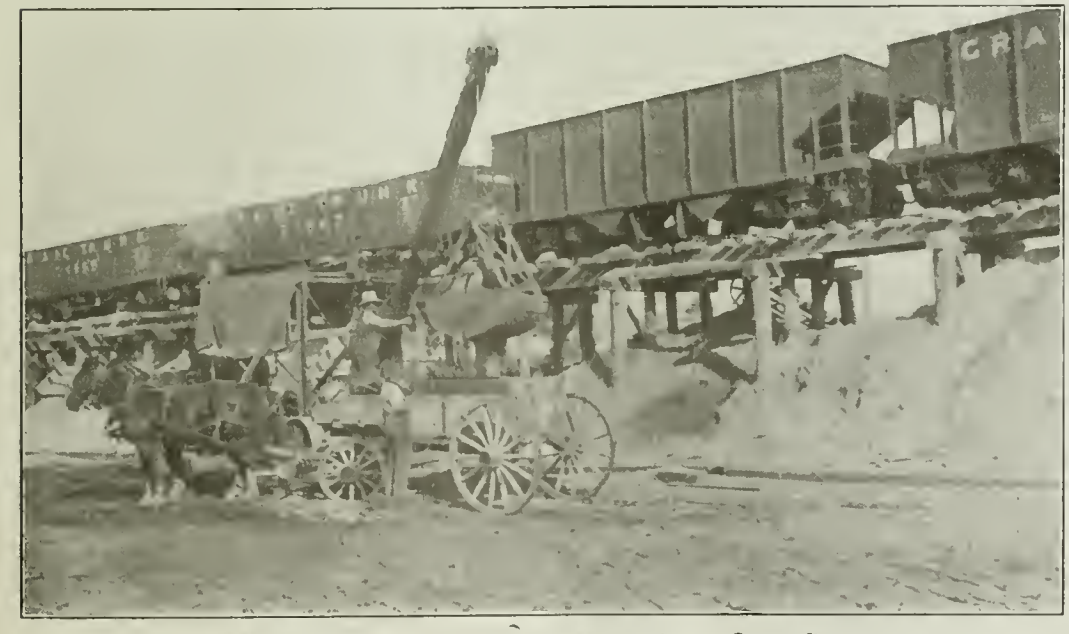
The British committee consists of a committee of the Privy Council, an advisory council of experts, and standing committees on engineering, metallurgy and mining.

The paper was followed by a lively discussion, after which the meeting went into business session and adopted the following resolutions:—

That the Manitoba Branch, Canadian Society of Civil Engineers, is heartily in accord with the idea of establishing research laboratories at the various industrial centres throughout Canada and would urge for favorable consideration, by those in charge, the establishment in Winnipeg of an experimental station for physical and chemical research relating to western industrial and civic problems.

That the Branch urge upon the Society in annual meeting assembled, consideration of the question of recommending to the Canadian Scientific and Industrial Research Committee the appointment of a standing committee on engineering and the nomination of certain members on such standing committee not exclusive of western representation.

That the chairman appoint a committee to make a special local study to forward the purposes of the Canadian Scientific and Industrial Research Committee.



Unloading Aggregates with a Byers Hoist at Camp Borden.

According to the railways statement made to parliament by the minister of railways, there were on March 31, 1916, 2,070 miles of railway in New Zealand, compared with 2,955 miles on March 31, 1915, an increase of fifteen miles.

STANDARD SPECIFICATIONS FOR ROAD MATERIALS

COMMITTEE OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS SUBMITS DRAFT OF PROPOSED SPECIFICATIONS FOR CRUSHED STONE, SAND, GRAVEL AND ASPHALTIC ROAD OILS—ABSTRACT OF THE COMMITTEE'S REPORT.

DURING the year 1916 a committee of the Canadian Society of Civil Engineers has been at work collecting data concerning the construction of various types of roads and streets, and formulating tentative standard specifications to guide the engineer in the purchase of road materials.

The members of the committee were W. A. McLean (chairman), W. P. Brereton, F. W. Doane, Jules Duchastel, J. E. Griffith, G. Henry, Edgar James, A. F. Macallum, A. J. McPherson, Paul Mercier, W. P. Near, George Powell and C. H. Rust.

Following is an abstract of the report prepared by this committee for the forthcoming annual meeting of the Society:—

The report of this committee for 1915 stated that printed forms would be sent to the municipal engineers throughout the Dominion with a view to securing data concerning the construction of pavements of various types. From year to year separate forms were to be sent on which data concerning the service rendered by these pavements would be itemized.

On further consideration it was decided to revise both forms and while the changes in the forms for recording data concerning construction were of a minor nature, consisting for the most part in a change in arrangement of items, that for recording data concerning the history of pavements was entirely revised. In place of the general information indicated on the original form the information has been itemized in detail. This will insure greater uniformity in the manner in which the information is received as well as facilitating the filling out of the forms by the engineers who are co-operating with the committee.

During the early part of the summer six copies of the form entitled "Data Concerning the Construction of Pavement" were sent to engineers in each of forty-three cities and towns in the Dominion as well as to members of the committee. A number of these have not been returned owing to changes of address of the engineers, the lack of detailed data or the absence of permanent street improvement in a number of municipalities. Hearty co-operation, which has been appreciated by the committee, has been received from a number of engineers, and much valuable information has been collected. Further co-operation is desired by the committee during the coming year.

The forms were sent out during the construction season and while a number of engineers expressed their willingness to furnish the information desired, they found it impossible to devote the time to the collection of it on account of the pressure of work. It was the intention of the committee that copies of both forms be in the hands of engineers shortly after the beginning of the new year, as at this period of the year more time is available for attention to office duties and the records of the previous season's work are still accessible. The list of the municipalities from which reports have been received, with the general location of the streets reported on and the type of pavement laid, is as follows:—

LIST OF PAVEMENTS REPORTED

Municipality.	Street or Road.	Pavement laid.
Montreal S., Que.	Rainville Bvd.	Concrete.
" " "	Desaulniers Bvd.	Asphaltic Concrete on 5" Concrete.
St. Lambert, Que.	Victoria Ave.	Bitulithic on 5" Concrete.
" "	Desaulniers Bvd.	Bitulithic on 5" Concrete.
Westmount, Que.	Upper Belmont	Sheet Asphalt on 6" Concrete.
" "	Wood St.	Sheet Asphalt on 6" Concrete.
Quebec Province	King Edward H'way	Bituminous Macadam.
" "	Sherbrooke to Derby line	Tar Macadam.
Quebec City	DeSalaberry	Granite Block on 6" Concrete.
" "	Salaberry St.	Asphaltic Concrete on 6" Concrete.
" "	St. Louis	Sheet Asphalt on 6" Concrete.
" "	Hermure	Asphaltic Concrete on 6" Concrete.
" "	Hamel	Asphaltic Concrete on 6" Concrete.
Stratford, Ont.	Wellington	Tar Filled Macadam on 5" Concrete.
" "	William	Tar Filled Macadam on 5" Concrete.
York County, Ont.	Vaughan Rd.	Tar Macadam.
" " "	Yonge St.	Waterbound Macadam.
North Bay, Ont.	McIntyre	Waterbound Macadam.
Welland, Ont.	N. Main	Wood Block on 5" Concrete.
" "	Cross	Brick on 5" Concrete.
" "	Hellems Ave.	Brick on 5" Concrete.
" "	Division	Brick on 5" Concrete.
" "	S. Main	Brick on 6" Concrete.
" "	Catherine St.	Brick on 6" Concrete.
" "	W. Main	Brick on 6" Concrete.
" "	E. Main (2 sections)	Brick on 6" Concrete.
Victoria, B.C.	Cormorant	Sheet Asphalt on 6" Concrete.
" "	Richmond Ave.	Sheet Asphalt on 5" Concrete.
" "	Cormorant	Sheet Asphalt on 6" Concrete.
" "	Richmond Ave.	Sheet Asphalt on 5" Concrete.
Oshawa, Ont.	Richmond	Concrete.
" "	Simcoe	Concrete.
Toronto, Ont.	Grace Terrace	Bitulithic on 5" Concrete.
" "	St. John's Rd.	Bitulithic on 5" Concrete.
" "	Keele St.	Bitulithic on 5" Concrete.
" "	Quebec Ave.	Sheet Asphalt on 5" Concrete.
" "	Keele St.	Sheet Asphalt on 5" Concrete.
" "	Earl St.	Sheet Asphalt on 5" Concrete.

Municipality.	Street or Road.	Pavement laid.
Toronto, Ont.	Alberta Ave.	Sheet Asphalt on 5" Concrete.
" "	Main St.	Sheet Asphalt on 6" Concrete.
" "	Wellington St. W.	Sheet Asphalt on 6" Concrete.
" "	Christie St.	Sheet Asphalt on 8" Concrete.
" "	Alexandra Bvd.	Concrete, 6" thick.
" "	Glencairn Ave.	Concrete, 6" thick.
" "	Lytton Bvd.	Concrete, 6" thick.
" "	Bracondale Hill Rd.	Brick on 5" Concrete.
" "	Bain Ave.	Brick on 5" Concrete.
" "	Scarborough Rd.	Brick (hillside) on 5" Concrete.
" "	Wells St.	Asphaltic Concrete on old Macadam foundation.
Kingston, Ont.	Aberdeen St.	Bituminous Concrete on 4" Concrete.
" "	William St. (3)	Bituminous Concrete on 4" Concrete.
London, Ont.	Ridout St. (2)	Asphaltic Concrete on 6" Concrete.
" "	York St.	Asphaltic Concrete on 6" Concrete.
" "	Bradford St.	Concrete.

Specifications for Materials.—The formulating of specifications for natural products, such as crushed stone, gravel, and sand, which can be directly used in all localities, is impossible. In many localities the greater portion of the cost of these materials is that paid for transportation. Hence material of high quality which can be procured within short distance of the work in one locality would reach a prohibitive cost in another.

The committee has therefore endeavored to draw up specifications which cover materials of good quality under normal commercial and natural conditions. It is recognized that in some districts these specifications as they stand will not be applicable, but the ideal striven for has been to secure a specification that may be a guide, from which specifications best suited to local conditions can be drafted.

The classifying of materials into different grades according to qualities reduces the necessity of redrafting the specifications. In localities where materials of certain grades cannot be secured economically and the nature of the work permits the use of material of inferior qualities, it will only be necessary to specify the particular grade required, when the specifications for work are drafted.

The extensive use of laboratory tests results may be considered inadvisable by some engineers. At the present time laboratories are not available in all municipalities, but resort to laboratory tests is rapidly growing and even at the present time tests are being conducted by some of the universities in the Dominion. It is felt that it is only a matter of time till every large municipality will submit all materials to laboratory test prior to accepting them.

The properties assigned to the different grades have been selected from the study of results of tests made under the direction of the chairman of the committee as well as from the study of the results of tests conducted by various highway organizations.

In reading the specifications it must be borne in mind that they are for the supply of materials only. The classes of work in which the materials are to be used, unless such materials are confined only to such classes, have not been stated. The specifications for the construction of various types of pavements will state definitely the class, size, etc., of the materials which are to enter into the construction of the particular pavements.

Drafts of the specifications as considered by the members of the committee residing in Toronto were sent to all members. Where suggestions regarding changes in minor points were made these have been incorporated, but where changes of importance have been suggested these are indicated at the end of each specification in order that they may receive the consideration of the society.

The committee reports progress in the drafting of specifications for the supply of bituminous materials. The rapidly increasing use of these materials for the protection of road surfaces renders it advisable that a reliable specification be in the hands of engineers at the earliest moment.

Work was commenced on three grades of asphaltic road oils, but at the same time it was realized that there were a number of other grades of this material as well as refined tars, etc., favored by engineers. The specifications which follow for bituminous materials have not been placed before all the members of the committee and are therefore to be considered as a progress report only.

It is the intention of the committee that a series of general clauses be drawn up which will take into consideration suggested form of tenders, suggested system of payments and methods of inspection of materials Following are the proposed tentative specifications:—

CRUSHED STONE.

Definition.—1-1.—Crushed stone shall be bedded rock or boulders which have been broken by mechanical means into fragments of varying shapes and sizes. It shall not contain more than 10 per cent. by weight of soft or friable material. Material of which the particles are coated with dirt or have the edges worn off will not be accepted.

Weathered Stone.—1-2.—No crushed stone shall be accepted which shows signs of being disintegrated or reduced in quality by the action of the weather.

Crusher Run.—1-3.—Crusher run shall be the product of the crusher, of which not more than 8 (eight) per cent. by weight shall pass a ¼ (one-quarter) inch opening.

Sizes of Stone.—1-4.—The following schedule of sizes shall be used, with the percentages of material larger than the maximum and smaller than the minimum openings respectively, as shown. The sizes of opening shall mean the diameter of circular openings in steel or iron plates. The percentages shall be determined by weight.

The sizes of stone with the openings by which they are obtained are as follows:—

Name of size	Maximum size of opening in inches	Maximum per cent. retained by max. size of opening	Minimum size of opening in inches	Max. per cent. passing minimum size of opening
5 inch	5	3	4	8
4 "	4	3	3	8
3 "	3	3	2½	8
2½ "	2½	5	2	10
2 "	2	5	1½	10
1½ "	1½	5	1	15
1 "	1	5	½	15
½ "	½	7	¼	15

Screenings.—Screenings shall be material all of which shall pass a ¼ (one-quarter) inch screen.

Mineral Dust.—Mineral dust shall be finely pulverized stone of which not less than 80 (eighty) per cent. by weight shall pass a 200 mesh screen.

Tests on Stone.—1-5.—In addition to fulfilling the foregoing requirements, crushed stone shall be classed into three grades, according to qualities which shall be determined by tests conducted in a properly equipped laboratory. The properties determined shall be: coefficient of wear, toughness and absorption. Material meeting the requirements of any of the grades with respect to coefficient of wear and toughness but failing to meet the requirement with respect to absorption may, on consideration of the engineer, be classed with the higher grade.

Grades of Crushed Stone.—Crushed stone shall be classed under one of the following grades:—

1-6.—Grade "A" is a rock which has a toughness of not less than 18 (eighteen), a coefficient of wear of not less than 14 (fourteen), and an absorption of not more than 0.6 (six-tenths) pounds per cubic foot.

1-7.—Grade "B" is a rock which has a toughness of not less than 10 (ten), a coefficient of wear of not less than 7 (seven), and an absorption of not more than 1.0 (one) pound per cubic foot.

1-8.—Grade "C" is a rock which has a toughness of not less than 7 (seven), a coefficient of wear of not less than 5 (five) and an absorption of not more than 1.5 (one and five-tenths) pounds per cubic foot.

1-9.—Grade "D" is a rock that does not meet the requirements of any of the above grades and which may be used only on consideration by the engineer.

GRAVEL.

Definition.—2-1.—Gravel shall consist of naturally formed fragments of tough durable rock, well graded in size from the smallest to the largest, free from flat, elongated particles, and shall not contain more than 15 per cent. by weight of soft friable material. It shall not contain an excess of clay nor an excess of loose or adhering dust, vegetable loam or other deleterious matter. It shall be satisfactory to the engineer in all respects.

Screened Gravel.—2-2.—"Screened gravel" is gravel fulfilling the above requirements which is screened into one or more of the sizes defined in Section 1-4 of the "Specifications for Crushed Stone."

2-3.—"Run of bank gravel" is gravel fulfilling the requirements of Section 2-1 of this specification, which shall be classed under one of the three grades shown below according to qualities determined in a properly equipped laboratory. The properties determined shall be the coefficient of wear and the proportions of the various sizes of particles present.

The coefficient of wear shall be determined on material passing a screen having circular openings 2 (two) inches in diameter and retained by a screen having circular opening ½ (half) inch in diameter. The test shall be conducted in the same manner as that for determining the coefficient of wear of crushed stone Run of bank gravel shall be classed according to the following grades:—

2-4.—Grade "A" is a run of bank gravel containing a large percentage of pebbles of igneous rocks. It shall not contain more than 5 (five) per cent. by weight of material which shall be retained on a screen having 4 (four) inch circular openings, and not more than 45 (forty-five) per cent. by weight of material which shall pass a screen having ¼ (one-quarter) inch square openings. It shall not contain more than 3 (three) per cent. by weight of clay or loam nor have a coefficient of wear of less than 14 (fourteen).

2-5.—Grade "B" is a run of bank gravel containing a smaller percentage of igneous rock pebbles. It shall not contain more than 5 (five) per cent. by weight of material which is retained by a screen having 4 (four) inch circular openings nor more than 60 (sixty) per cent. by weight of material retained by a screen having ¼ (one-quarter) inch square openings. It shall not contain more than 9 (nine) per cent. by weight of clay or loam nor have a coefficient of wear of less than 11 (eleven).

2-6.—Grade "C" is a run of bank gravel composed chiefly of pebbles of sedimentary rock. It shall not contain more than 5 (five) per cent. by weight of material which is retained on a screen having 4 (four) inch circular openings, and not more than 80 (eighty) per cent. by weight of material which passes a screen having ¼ (one-quarter) inch square openings. It shall not contain more than 12 per cent. by weight of clay or loam nor have a coefficient of wear of less than 7 (seven).

2-7.—Grade "D" is a run of bank gravel which does not meet the requirements of any of the above grades and which may be used only by written permission of the engineer.

2-8.—When so directed by the engineer, gravel shall be crushed. The material so produced shall conform to the requirements of "screened gravel" or "Run of bank gravel" as directed by the engineer.

SAND.

Concrete Sand.—3-1.—Fine aggregate for concrete shall consist of natural sand, composed of hard, tough, durable particles, graded from fine to coarse. When dry, not more than 5 (five) per cent. shall be retained on a sieve having 4 (four) meshes per lineal inch; not more than 20 (twenty) per cent. by weight shall pass a sieve having 50 (fifty) meshes per lineal inch, and not more than 4 (four) per cent. shall pass a sieve having 100 (one hundred) meshes per lineal inch. It shall not contain more than 3 (three) per cent. by weight of clay or loam.

Mortar Tests.—3-2.—Sand in addition to meeting the above requirements shall give a mortar strength equal to or higher than the minimum value at any of the ages shown in the following table:—

Age at test.	Minimum strength of 1 : 3 mortar.
72 hours	1.25 times A
7 days	1.10 times A
28 days	1.00 times A

Where "A" is the strength of 1 : 3 standard Ottawa sand mortar specimens of same form and size made by the same operator using the same cement and the same amount of water.

The tests shall be made on mortars composed of 1 (one) part Portland cement and 3 (three) parts of fine aggregate or standard Ottawa sand, by weight. The test specimens shall be made, stored and tested in the same manner, under approved laboratory conditions and according to recognized standards of practice. Each value shall be the average from tests of no fewer than 3 (three) specimens.

Cement.—3-3.—The cement used in all tests shall meet the requirements of the specifications for Portland cement of the Canadian Society of Civil Engineers, as revised in 1916.

Stone Screenings.—3-4.—Stone screenings from a hard, tough, durable rock may be used as fine aggregate by written permission of the engineer and provided it meets the requirements of mortar strength.

Sand for Bituminous Construction.—3-5.—Sand for use in bituminous pavement construction shall consist of hard, tough, durable particles. It shall not contain more than 1 (one) per cent. of clay or loam. When dry, not more than 8 (eight) per cent. shall be retained on a sieve having 8 (eight) meshes per lineal inch, and shall not vary more than 5 (five) per cent. from the following:—

Screen mesh per lineal inch.	Percentage by weight retained.
8	10
30	20
50	27
80	20
100	15
200	7
	1
	100 Pass

Cushion Sand.—3-6.—Cushion sand shall be clean and sharp, and not more than 10 (ten) per cent. by weight shall be retained on an 8 (eight) mesh sieve. It shall not contain more than 10 (ten) per cent. by weight of clay or loam.

Grout Sand.—3-7.—Grout sand shall be clean, sharp and well graded. Not more than 8 (eight) per cent. by weight shall be retained on a 20 (twenty) mesh sieve, and not more than 30 (thirty) per cent. on a 100 (one hundred) mesh sieve. It shall not contain more than 5 (five) per cent. of clay or loam.

Mortar made in the proportion of 1 (one) part of cement to 3 (three) parts of sand by weight shall show a tensile strength at least equal to 40 (forty) per cent. of a similar mortar made of standard Ottawa sand, mixed in the same proportions and stored and tested in the same manner.

ASPHALTIC ROAD OILS.

General.—Asphaltic oils shall be classed into three grades, each containing the minimum percentage by weight of asphalt, of 50 degrees penetration, as follows:—

Light oil shall not contain less than 40 per centum asphalt.
Medium oil shall not contain less than 60 per centum asphalt.
Heavy oil shall not contain less than 80 per centum asphalt.

All oil, in addition to meeting the requirements of one of the above grades, shall have the following characteristics as determined in the laboratory. All tests shall be conducted according to the latest methods recommended by the American Society for Testing Materials.

The requirements are as follows:—

1. It shall be obtained by the refining of asphaltic or semi-asphaltic petroleum or by the combination of solid or

semi-solid native asphalts with asphaltic petroleums or derivatives thereof, which melt on the application of heat.

2. The various hydrocarbons composing it shall be present in a homogeneous solution.

3. It shall be free from water and sediment.

4. It shall not contain acid nor sulphur in sufficiently large quantities to attack rubber or rubber compositions.

Light Oil.—Light oil shall have the following characteristics:—

1. It shall have a specific gravity of not less than 0.92 (ninety-two one hundredths) at 77 degrees Fahrenheit (25 degrees C.).

2. When evaporated in an open vessel at a temperature between 450 and 500 degrees Fahrenheit until the residue remaining has a penetration (5 seconds, 77 degrees Fahrenheit, No. 2 needle, 100 grams) of 50 (fifty) degrees, the residue shall meet the following requirements:—

(a) It shall amount to not less than 40 (forty) per centum and not more than 50 (fifty) per centum of the original oil by weight.

(b) It shall have a ductility at 77 degrees Fahrenheit of not less than 25 (twenty-five) centimetres (Dow mould).

(c) It shall have a melting point of not more than 160 (one hundred and sixty) degrees Fahrenheit and not less than 130 (one hundred and thirty) degrees Fahrenheit when tested by the ball and ring method

3. Fifty grams of the oil upon being maintained at a temperature of 325 degrees Fahrenheit for 5 hours in a cylindrical vessel 2¼ inches in diameter and 1½ inches deep shall not lose more than 25 (twenty-five) per centum nor less than 10 (ten) per centum by weight.

4. It shall be soluble at air temperature in pure carbon bisulphide to the extent of not less than 99.0 (ninety-nine) per centum.

5. It shall be soluble at air temperature in 76 degrees Beaume paraffin petroleum naphtha distilling between 140 and 190 degrees Fahrenheit to the extent of not less than 85 (eighty-five) per centum and not more than 95 (ninety-five) per centum.

6. It shall yield not more than 8 (eight) per centum by weight of fixed carbon on ignition.

7. It shall show a flash point of not less than 120 (one hundred and twenty) degrees Fahrenheit when tested in an open cup.

8. It shall not contain more than 5 (five) per centum by weight of paraffin scale.

Medium Oil.—Medium oil shall have the following characteristics:—

1. It shall have a specific gravity of not less than 0.94 (ninety-four one hundredths) at 77 degrees Fahrenheit.

2. When evaporated in an open vessel at a temperature between 450 and 500 degrees Fahrenheit until the residue has a penetration (5 sec., 77 degrees Fahrenheit, No. 2 needle, 100 grams) of 50 degrees, the residue shall meet the following requirements:—

(a) It shall amount to not less than 60 (sixty) per centum and not more than 70 (seventy) per centum by weight of the original oil.

(b) It shall have a ductility at 77 degrees Fahrenheit of not less than 25 centimetres (Dow mould).

(c) It shall have a melting point of not more than 160 (one hundred and sixty) and not less than 130 (one hundred and thirty) degrees Fahrenheit, when tested by the ball and ring method.

3. Fifty grams of the oil upon being maintained at a temperature of 325 degrees Fahrenheit for 5 hours in a cylindrical dish 2¼ inches in diameter and 1½ inches deep, shall not lose more than 12 (twelve) per centum nor less than 7 (seven) per centum by weight.

4. It shall be soluble at air temperature in pure carbon bisulphide to the extent of not less than 99.0 (ninety-nine) per centum by weight

5. (a) It shall be soluble at air temperature in 76 degrees Beaume paraffin petroleum naphtha to the extent of not less than 83 (eighty-three) per centum and not more than 90 (ninety) per centum.

(b) When 20 C.C.'s of naphtha solution, obtained by treating 1 gram of oil with 100 C.C.'s of 76 degrees Beaume petroleum paraffin naphtha at air temperature, is evaporated upon a glass plate, the residue shall be adhesive and sticky, but not oily.

6. It shall yield between 8 (eight) per centum and 12 (twelve) per centum by weight of fixed carbon on ignition.

7. It shall show a flash point of not less than 150 (one hundred and fifty) degrees Fahrenheit when tested in an open cup.

8. It shall not contain more than 5 (five) per centum by weight of paraffin scale.

Heavy Oil.—Heavy oil shall have the following characteristics:—

1. It shall have a specific gravity of not less than 0.96 (ninety-six one hundredths) at 77 degrees Fahrenheit (25 degrees Cent.).

2. When evaporated in an open vessel at a temperature between 450 and 500 degrees Fahrenheit until the residue has a penetration (5 seconds, 77 degrees Fahrenheit, No. 2 needle, 100 grams) of 50 (fifty) degrees the residue shall have the following requirements:—

(a) It shall amount to not less than 80 (eighty) per centum by weight of the original oil.

(b) It shall have a ductiliy at 77 degrees Fehrenheit of not less than 40 (forty) centimetres.

(c) It shall have a melting point of not more than 160 (one hundred and sixty) and not less than 130 (one hundred and thirty) degrees Fahrenheit when tested by the hall and ring method.

3. Fifty grams of the oil upon being maintained at a uniform temperature of 325 degrees Fahrenheit for 5 hours in a cylindrical vessel, 2¼ inches in diameter by 1½ inches deep, shall lose not more than 5 (five) per centum by weight.

4. It shall be soluble at air temperature in pure carbon bisulphide to the extent of not less than 99.0 (ninety-nine) per centum by weight.

5. (a) It shall be soluble at air temperature in 76 degrees Beaume paraffin petroleum naphtha to the extent of not less than 75 (seventy-five) per centum and not more than 90 (ninety) per centum by weight.

(b) When 20 C.C.'s of naphtha solution, obtained by treating 1 gram of oil with 100 C.C.'s of 76 degrees Beaume petroleum paraffin naphtha at air temperature, is evaporated upon a glass plate, the residue shall be adhesive and sticky but not oily.

6. It shall yield between 8 (eight) per centum and 14 (fourteen) per centum by weight of fixed carbon on ignition.

7. It shall have a flash point of not less than 290 degrees Fahrenheit when tested in an open cup.

8. It shall not contain more than 5 (five) per centum by weight of paraffin scale.

The United States has furnished nearly 80 per cent. of Great Britain's imports of semi-finished steel since the war started, whereas previous to the war the United States furnished less than 20 per cent. of such imports and Germany nearly 80 per cent

Invar is a nickel steel containing about 36 per cent. nickel, together with about 0.5 per cent. each of carbon and manganese. Its most remarkable property is its extremely small thermal expansion at ordinary temperatures, owing to which quality it is now used for making steel tapes for precision measurements. Its mechanical properties are about as follows: Tensile strength, 50,000 to 85,000 lbs. per sq. in.; elongation, 40 to 50 per cent.; reduction of area, 40 to 65 per cent.; and Brinell hardness, 160.

The largest electrically-driven reversing rolling mill at present in operation in America is that of the Bethlehem Steel Company, at Lehigh. It is a 35-in. blooming mill. Altogether there are at work, or in course of erection, eighteen electrically-driven reversing mills in the United States and Canada. According to Mr. Jefferies, of the Steel Company of Canada, the power required for a rolling mill owned by this company working much below its normal capacity amounts to 21.5 kilowatt hours per ton.

A bill to permit American power plants to withdraw 20,000 feet of water per second from Niagara Falls, the full amount permitted by a treaty with Great Britain and Canada, was passed on January 4th by the house at Washington, 274 to 82. The present use of 15,600 feet per second is insufficient, it was argued, to supply industries on the American side which have been deprived of power from the Canadian side now diverted to war plants. The power companies must pay $100 a year per cubic foot. The bill now goes back to the Senate.

REPAIRING TIMBER CRIBWORK

By A. E. Eastman, A.M.Can.Soc.C.E.

THE cribwork referred to in this article is on the north side of the lower entrance to one of the old locks of one of the canals of the St. Lawrence River canal system. While this lock is not used except in case of emergency, this entrance and cribwork are in general use as a dock for the landing of local freight from river boats, and also as the landing place for a ferry, making six to eight trips daily. These facts were necessary to consider when carrying on the work, and also the use to which the completed work would be put.

maximum is again reached. This maximum varies, generally following a six or seven-year cycle.

The work done on the cribs as described was carried out in the fall, when the water was comparatively low.

While there was no current along this cribwork, there was an almost constant fluctuation or "tide," the rise and fall being three or four inches and occurring at about twenty-minute intervals. Owing to this "tide" practically all elevations were taken by instruments, soundings being used but little.

Work was begun by tearing down Crib No. 1 and the bridge over the opening between Cribs 1 and 2. A floating derrick was used to assist in this, as well as handling material, or any work possible to use it for. This tearing

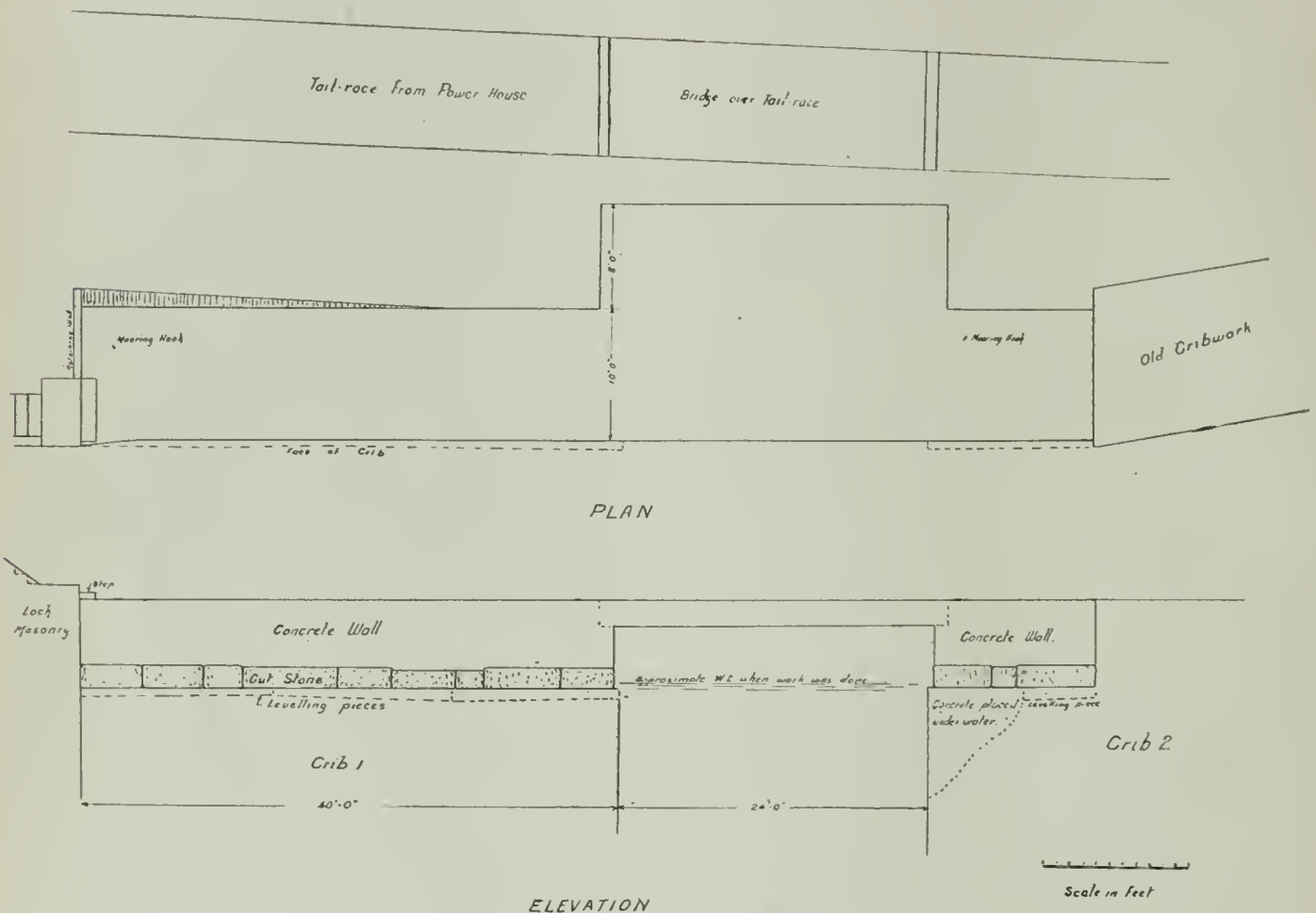


Fig. 1.—General Plan of Work.

The cribwork as a whole consisted of a number of timber cribs about 40 ft. x 12 ft., about 24 ft. apart, this space being bridged with timber stringers and a floor of plank. The work described refers to cribs 1 and 2 only, these being nearest the lock masonry.

The cribs had been built for a good many years and were in need of repair. In general, it may be said that the plan adopted for these repairs was to tear the cribs down to below water and build a superstructure of concrete, stone and steel, the elevation of the top of the new structure to be the same as that of the old.

The St. Lawrence River is not subject to spring freshets as smaller streams are; the high-water stage of the year being in June and the water then gradually falling till the lowest stage is reached in about February or March, when the water begins to rise again until the

down was a somewhat slow process. The timbers having been well bolted, and the stone filling had to be removed by hand and piled to one side for future use. Fair-sized boulders were found to have been used in crib filling, and below water caused some trouble. Another cause for slow progress was the smallness of the service grounds, as old material could not be placed where it would interfere with delivery of new material, or the progress of the work.

The whole top of the crib was not removed, but only sufficient to allow the new wall to be built along the face of the crib and the end next to Crib No. 2.

As before stated, the crib was torn down till a sound course was encountered under water, which varied from a few inches to a couple of feet at the then stage of the water. After all material necessary had been removed, elevations were taken every foot along the top of the crib

as left, and the results platted. Levelling sticks were then framed and well bolted in place with ¾-inch drifts. These levelling pieces were to come to within about six inches of the water surface. The well-known method of driving these bolts was used, an iron pipe with a rammer. It may be said that in planning the work no elevations could be pre-determined except the elevation of the top of the finished work, all others being governed by circumstances as they arose.

When possible to avoid it, it was not desired to place concrete below water line, and to overcome this, cut stones were placed on these levelling pieces. These were stone of first-class quality that had been prepared for use in the lock walls and other masonry when the canals were enlarged some years ago, but had not been used. These stone varied from 16 ins. to 22 ins. in thickness, but all of one thickness were grouped together as much as possible and were placed with the face six inches back of the face of the crib, or if there were a variation from a straight line in the crib they were placed at such distance that the finished work would be straight. The floating

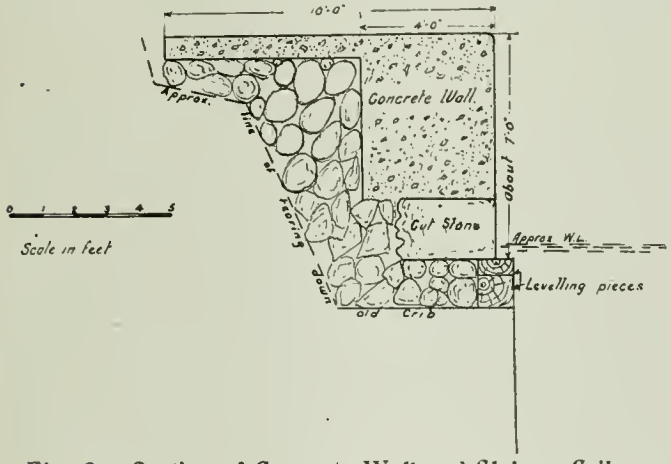


Fig. 2.—Section of Concrete Wall and Slab on Cribs.

derrick came into use in placing these stone. It was also the idea in using these stone to have them occupy as much as possible of the space between maximum high and minimum low water, mentioned in a previous paragraph.

After these stone were placed, the forms for the wall were put up and the concrete wall was poured. The concrete for the whole work was about a 1:3:5 mixture, gravel being used instead of sand and crushed stone. The concrete was mixed by hand and either shovelled directly into the forms, or wheelbarrows were used when more convenient. To give a good face to the wall the concrete was well worked along the face forms. No reinforcing was used in the wall or slab on the cribs, but "plums" were permitted, some of the old crib filling being used.

Fig. 1 shows the general plan of the finished work and Fig. 2 a typical cross-section of the concrete wall and slab on cribs No. 1 and No. 2 as built.

As mentioned, this cribwork is used as a dock, but for small boats as a rule, so instead of mooring posts, iron hooks for mooring were placed. These hooks worked freely around the top of a vertical 2-inch iron pin about 2 feet long, securely anchored when the concrete was placed. The hooks are sufficient for all traffic using the dock.

On the end wall on Crib No. 1 a bridge seat was made to carry the I-beams that were to form the stringers of the bridge across the opening between cribs 1 and 2. The bridge could not be placed, however, till the wall on Crib No. 2 was finished, so after the concrete on Crib No. 1 had set, work was begun on Crib No. 2.

As shown on Fig. 1, there is an angle in Crib No. 2 and this angle was fixed as the finishing point for the work for the season and so Crib No. 2 was torn down only as far as this angle.

Work of tearing down this crib was carried on as on Crib No. 1, but the outer corner was found to be in very poor condition and sound timber was not found till a point four or five feet below water was reached. It was found that, owing to the condition of the crib, it would be advisable to build this corner up with concrete

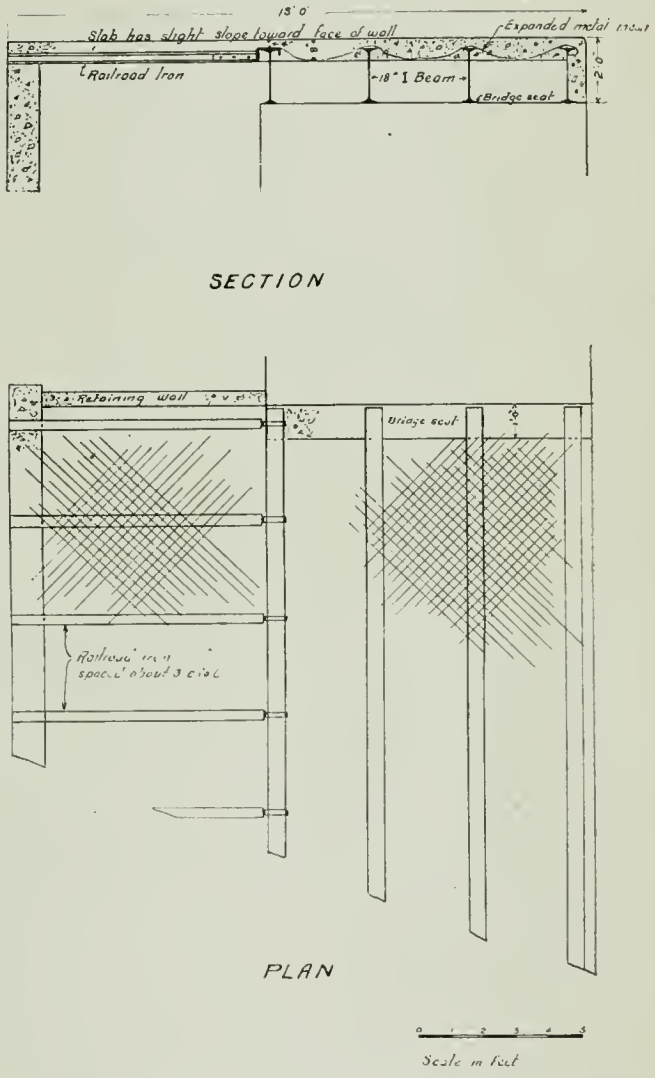


Fig. 3.—Details of Steel.

rather than with timber; cut stone, however, to be placed at the same corresponding position as on Crib No. 1 for the same reasons. To hold this concrete, a form of plank, placed vertically, was built, a diver fastening the bottom ends of the plank, while the top ends, being well above water, were secured to the crib. The concrete was deposited through a pipe and allowed to set well before the form was removed.

After removing the form the cut stone were placed and the wall erected as on Crib No. 1. The wall ended vertically at the angle mentioned and will serve as an expansion joint when this work is continued.

On beginning the work of bridging the opening between Cribs 1 and 2 several points had to receive consideration. As will be seen from Fig. 1, the tailrace from a power house runs just back of the cribwork, and care had to be taken to prevent the wall of this tailrace, which is built of light timber, from giving way and allowing the water to run between Cribs 1 and 2. Also, the top slab would here need to be wider than on the cribs and provision must be made to carry this additional width; the walls of the tailrace could not be interfered with in any way or touched by the new work. It was decided to make the slab at the opening about eight feet wider than on the cribs, and a wall one foot wide, built to the required elevation and a little longer than the opening between the cribs, was built eight feet back of the crib slabs to carry the bridge slab. Very light walls, to prevent material running around the ends of this supporting wall, were built connecting it with the end wall on the cribs.

Across the opening directly between the cribs four 18-inch I-beams were placed to carry the slab and from the rear I-beam pieces of railroad iron a little less than 8 feet long were placed to carry the extra width. These were supported at one end directly on the concrete wall and were attached to the I-beam by a hook over the top of the beam, and securely bolted to the railroad iron web. Expanded metal mesh was used for additional reinforcement between the I-beams and railroad iron. Fig. 3 shows the details of the steel work.

The reason for placing such heavy beams was that this bridge was in more constant use than any other part of the structure and heavy freight is occasionally landed there.

The concrete in this bridge was mixed and placed in the same manner as on the walls on the crib.

Where the new work joins the old masonry a concrete step was placed and a small retaining wall built to hold up a small quantity of earth that was above the level of the completed work.

This old lock masonry has a batter of about one in twenty and the new wall was planned with a plumb face. The connection was made by slightly twisting the forms to conform to the batter, and running to plumb as soon as possible.

The grounds around were graded up where necessary and all unused material removed, leaving all sightly.

This completed the work as planned for the season.

The work was performed under the direction of Mr. C. D. Sargent, superintending engineer of the Ontario-St. Lawrence Canals. The writer did the instrument work, and looked after the details as the work proceeded. The labor was done by the repair staff of the canal, Mr. J. C. Boyd being overseer of this canal.

BUILDING INDUSTRY DURING PAST YEAR.

The building industry throughout Canada for the last year has shown a substantial increase over the very low figures registered for 1915. This is ascribed principally to the increased demands of war industries, but domestic requirements have been responsible for no small part of the increased activity. One important feature of the development of the industrial life of the Dominion is the large number of United States manufacturing concerns which are establishing branches in Canada, partly as the result of a realization of the advantages which are bound to accrue in the ordinary course of events from the industrial expansion which is regarded as inevitable after the war, and also the possibility of trade arrangements which will promote commerce between the allied countries.

EXPERIMENTS ON EARTH PRESSURES.

In a paper read before the Institution of Civil Engineers, Mr. P. M. Crosthwaite gives a short account of Rankine's theory of earth pressure, and the principles and assumption on which it is founded, together with descriptions of former investigations—namely, those of the late Sir George Darwin, and Messrs. Goodrich, Wilson, Bell and Meem. The author concludes that of the experiments made by these investigators to investigate the lateral pressure of earth, those in which model walls were used are of greatest value, but points out that if models are of any size the experimental difficulties are almost insuperable.

The author's experiments, a number of which are described and illustrated in the paper, were made by loading a plunger with known weights and measuring the penetration when the plunger had come to rest after the application of each weight. The materials were enclosed in an open bucket, and their weight was determined.

With those data the value of ϕ, the angle of internal friction, can be obtained from Rankine's well-known formula for the safe depth of foundations—

$$d = \frac{P}{W}\left(\frac{1 - \sin.\ \phi}{1 + \sin.\ \phi}\right)^2$$

when d denotes the penetration, P the pressure in pounds per square foot, and W the weight of the material in pounds per cubic foot. If the formula is true, and the pressures be plotted against the penetrations, the resulting curve is a straight line, and ϕ as calculated from the formula should equal the angle of repose.

With sand, garden earth, and cinders and ashes the resulting curves are straight lines, but it was found that the value of ϕ varied with the state of aggregation of the material—*i.e.*, whether it was lightly poured into the bucket, shaken in, or well pounded in. When the material was deposited in the bucket as lightly as possible the angle of internal friction was the same as the angle of repose, but with more consolidation the angle was much greater.

From these materials the author concludes that Rankine's theory holds, provided the proper angle of internal friction is used and not the angle of repose. If, however, this angle is used it would be necessary to introduce a factor of safety into the formula, for a wall designed without one would be theoretically just strong enough and no more. In Rankine's formula there is no factor of safety, and it is concluded that Rankine saw this, and used the angle of repose as covering the worst conditions that need possibly be provided for. The author's experiments show that, for the materials tested, work designed by Rankine's formula, using the angle of repose, would have a factor of safety of 2½ to 4, and he considers that these are not unreasonable figures for such materials.

The experiments on clay give altogether different results, for instead of the penetration varying at the load, it varies as the square of the load, and the penetration curves are parabolas. Those results, which were altogether unexpected, are completely confirmed by larger experiments carried out by Messrs. Coode, Matthews, Fitzmaurice and Wilson, and by Mr. McAlpine in New York.

The author is unable to give any physical explanation as to why the penetration in clay should vary as the square of the load, but leaves it to the physicists. The law must be capable of some rational explanation, and, if true, it upsets all earth-pressure theories when they are applied to clay; for all accepted theories assume that the angle

of internal friction is the same as the angle of repose, and that its value is independent of the pressure. It is suggested that the subject is worthy of further investigation, but that such could hardly be made by a private individual, for the work is tedious, each experiment taking from 24 to 48 hours. Moreover, if the investigation is to be properly carried out, physical and chemical analyses of the clays will be required that could only be made in a well-equipped physical laboratory.

In connection with the earth slides experienced at the Panama Canal, it has been suggested that in clay and shale cuttings there is a critical depth beyond which the sides will not stand, and the author's experiments on clays clearly show that for these this must be the case. Where ϕ is independent of the pressure, the depth of the cutting cannot affect the stability of the slope, but where the angle decreases with the pressure, it is evident that eventually a depth will be reached beyond which its sides will not stand.

This decrease is clearly shown in one experiment on mud, for which the angle for a pressure of 0.25 ton per square foot was 17 degs. — 15 min., which decreased to 2 degs. 10 min. at a pressure of 1.25 tons per square foot, when it was little better than a liquid.

NO ROAD SHOW AT WINNIPEG.

It has been decided not to hold the Canadian and International Road Congress at Winnipeg this year, announced Secretary McNamee at Toronto this week. The first congress was held in Montreal in 1914, the second in Toronto in 1915, the third in Montreal last winter, and it was voted at the third congress that the fourth be held in Winnipeg. Secretary McNamee visited Manitoba recently, and now states that there is no building in that city which could house the exhibits, and that other conditions also make it inadvisable to go west this year. It has not been decided yet just where the congress will be held this year, but Ottawa is now being favorably mentioned.

ANNUAL MEETING, TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The annual meeting for the election of officers for the ensuing year was held at the Engineers' Club on January 11th. Following will be the executive officers for the year:—

Chairman, E. W. Oliver; secretary-treasurer, L. M. Arkley; executive, H. G. Acres, A. H. Harkness, T. T. Black and E. G. Hewson.

G. A. McCarthy, retiring chairman, will also act as a member of the executive.

Reports of the various committees were received. G. A. McCarthy was elected to represent the Toronto branch on the committee of technical society representatives, recently organized to devise means by which engineers who have not enlisted or undertaken munition work may help in carrying on the war. It was suggested that a committee be appointed by the executive to aid in making members of the branch better acquainted, and the new executive will probably deal favorably with the suggestion.

POINTS OF INTEREST IN CONNECTION WITH SOME CONCRETE BUILDINGS RECENTLY ERECTED IN AND AROUND MONTREAL.

(Continued from page 49.)

In the second half of January, 1914, the weather was very severe, and the top layer of concrete was quite frozen as soon as laid down. The only precautions taken were to heat the sand, stone, and water, and thoroughly clean the forms, tiles and steel with a powerful steam jet. The floor when completed was left without any protection for the balance of the winter. When work was resumed the concrete floor was perfect, and the concrete was harder and better than in similar floors made in very hot weather, when no special precautions are taken to protect the concrete from drying out.

These two buildings represent proof that not only mass concrete but concrete floors from 2 ins. to 4 ins. thick may be made in winter without any other precautions than heating the materials. Any additional protection after the concrete is placed is not necessary, provided the forms will remain until the concrete has set and acquired the necessary strength to carry the imposed loads.

In cases where completion is essential, by a given date, and the forms have to be removed as soon as possible, special arrangements have to be made to cure the concrete during the cold weather. Arrangements of this kind were necessary during the construction in Montreal of a seven-story building, at the corner of St. Lawrence and Duluth Streets. The building was started November 7th, 1913, and possession had to be given on May 1st, 1914. There were about 2,000 yards of rock to excavate. Concreting was not started until the end of December, 1913, and was carried on during the winter season.

The outside walls being also of concrete, the following methods were followed:—

Before any concrete was placed the forms for two floors including walls were completed, the upper floor serving as a protection to the lower one. The supports of the upper floor were placed on concrete blocks. A complete hot air heating system was installed in the basement, and during the placing of the concrete, as well as during the curing, a temperature of about 40° F. was maintained in the building. All materials were heated, and the forms as well as all stop joints were thoroughly cleaned with a powerful steam jet. This method was used from beginning to end, and the success was complete. The work was going on day and night, irrespective of the weather, and some of the floors were poured when the outside temperature was about 20° below zero. Test blocks were made on each floor, and left under the same conditions as the floor. Before the forms of a floor were struck, the blocks were investigated. The test blocks as well as the walls and floors showed clearly that in winter the setting of the concrete takes place from the inside to the outside. The heat generated by the chemical process of the setting of the cement probably maintains the inner temperature above the outside temperature, and these conditions are probably more favorable to the setting of the concrete than the ordinary summer conditions, when the outside of the concrete is drying out and setting quicker than the inside. There is also another fact in favor of winter-made concrete and that is the elimination of laitance. This elimination of laitance is more thorough in winter than in summer. In columns poured in winter the laitance on the top will be 2 ins. to 3 ins. thick, whereas in summer on a

column of the same dimensions, and the same quality of cement, the laitance will hardly be ¾ in. to 1 in. thick. If not removed carefully this laitance accumulating at the top of columns and sometimes at the bottoms of beams may cause trouble, and the success of winter-made concrete is to some extent dependent upon the careful removal of the laitance. If concrete work can be carried on successfully in winter, cement finish should not be attempted at all.

The success of a cement finish depends on the adhesion between the relatively thin coat of cement mortar and the concrete base. It is easy to understand that the freezing of the thin mortar finish will separate it from the base, and failure must result. It is the bond between the cement finish and the base, which is affected by frost, and not the cement finish itself.

The question of winter-made concrete is very important, especially for Canada, where in many provinces the winter season is longer than the summer, and it is now well established that concrete operations can be and are being carried on successfully in winter.

St. Michael's Church.—A striking example of the adaptability of concrete to complicated structure is given by the St. Michael's Church now being constructed at corner of St. Urbain and St. Viateur Streets, in Montreal.

The church proper covers an area of about 170 ft. x 90 ft. (exterior dimensions). There are really no columns in this church, and the whole structure is built of plain and reinforced concrete. The style is Byzantine. The layout, from the general engineering point of view, was made in detail by the architect, Mr. A. Beaugrand-Champagne. The design of the dome and supporting arches was by Prof. E. Brown.

The church is founded on rock. The basement ceiling is carried by flat arches 54 ft. clear span, having a rise of 30 ins. The arches are 18 ft. centre to centre, and are connected with a flat slab 7 ins. thick.

The main auditorium is covered by a dome 74 ft. diameter. This dome is carried by four full centre arches, each 52 ft. diameter, which arches are being carried down to rock by four strong tower abutments. The dome is about 118 ft. above the sidewalk and 110 ft. above the auditorium floor.

The tower is 170 ft. high. The outside walls are all covered with Greendale brick and terra cotta. The domes and roofs, however, are finished in concrete, the domes having received a colored waterproof cement finish about 1 in. thick, showing green shamrocks on a white field. The green color was obtained by mixing a green pigment with the ordinary cement, and the white coloring is obtained by the use of Atlas white cement.

The main cupola is carried on a series of semi-circular arches fixed rigidly into a heavy ring of concrete reinforced with steel bars in the form of circular hoops. There are six semi-circular arches, 36 ins. deep, 12 ins. wide at the bottom, and 6 ins. wide at the crown. At the crown the arches are connected by a disk 4 ft. diameter and 36 ins. deep.

For the computing of the stresses in the concrete and steel the total weight of the cupola, including suspended ceiling, wind, snow, etc., was taken at 150 lbs. per square foot, the cupola being of uniform thickness of 5 ins.

The six semi-circular ribs are reinforced with four 1⅜-in. square twisted bars, two near the top and two near the bottom and connected with stirrups about every 12 ins. The cupola, which is of a uniform thickness of 5 ins., is reinforced with half-round bars at 6-in. centre to centre.

To ascertain that under the most unfavorable conditions the stresses in the concrete and steel will always remain within the safe limits many assumptions were made.

The cupola was first designed without ribs and of a uniform thickness of 8 ins., following the theory given by E. Collignon "Cours de Mecanique, p. 631." The theory as given by Collignon shows that in a spherical cupola the stresses in the material used are independent of the thickness of the cupola, and are determined only by the diameter of the cupola and the specific gravity of the material used. With hoops made of ½ square bars, and placed 9 ins. centre to centre, the stresses in the steel concrete would be kept within the safe limits. The thickness of the cupola will be rather governed by the stiffness to be attained than by the safe stresses. However, taking into consideration the large proportions of the cupola, it was decided to provide arch ribs as described above, and making assumptions rather more severe than the actual conditions warranted, the stresses in the steel and concrete were kept within the safe limits. Notwithstanding this fact that the cupola was designed assuming unfavorable conditions, from an economical point of view the concrete cupola was the cheapest. As built, the cupola is about 40% cheaper than a Gostavino tile cupola, and about 50% cheaper than a steel structure fireproofed with concrete or tiles.

The half spherical cupola at the rear having a diameter of 52 ft. and the small 20-ft. cupola at the top of the tower are of uniform thickness, and are reinforced with hoops made of round ½-in. bars.

The four main arches carrying the cupola, the cantilevers and the arches in the basement were designed following the established methods. The winding stairs and the large windows were also made of reinforced concrete, although no established formula were available.

The Long Sault Development Co.'s project for the construction of a dam across the St. Lawrence River in connection with its power development scheme, has been finally quashed, the U.S. Supreme Court having dismissed the company's appeal against the ruling of the New York courts annulling its franchise. This matter has been before the courts for several years, and has been persistently fought at every stage by the Dominion Marine Association and the Shipping Federation of Canada, on the ground that it would interfere considerably with the safe navigation of the St. Lawrence River.

The committee on sewage works operation of the American Public Health Association has made an analysis of sewage treatment plants in the following fifteen states: California, Illinois, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Texas, Virginia and Wisconsin. The total number of plants reported was 1,294. Of these, one-third are designed for populations of less than 500; over one-half for populations between 500 and 10,000; and only 7 per cent. for populations over 10,000. Only 29 of the 1,294 plants are equipped with complete laboratories, and of this number 17 are in the State of Pennsylvania.

The Governor-General of Korea has issued new mining laws to supplant those of 1906. They consist of 64 articles based on the mining law of Japan. The most important provision is that in future foreigners as individuals will be prohibited from obtaining mining concessions in the country, and the granting of such concessions is to be limited to Japanese subjects born or "legalized," and the latter must have their head office in Korea. Mining-rights already in existence and held by foreigners are not to be interfered with. Priority of application will probably no longer ensure the grant of mining rights, although this is not expressly stated in the new ordinance.

Editorial

CANADIAN SOCIETY OF CIVIL ENGINEERS.

Every member of the Canadian Society of Civil Engineers whose time is not occupied in munitions or other war work should make a special effort to attend the thirty-first annual meeting of the society in Montreal next week.

To be present at a national gathering of the men of his profession is a duty that every member owes not only to himself but to the profession. The three days of association with his fellow engineers next Tuesday, Wednesday and Thursday will greatly benefit each and every one.

Not to speak of the change of scene and air and the other benefits of a little vacation of this sort, the new ideas that will be gathered by each engineer who attends the meeting, and the stimulus and inspiration to be obtained from the contact with many of his most successful fellows, will return to the traveller a big dividend upon the comparatively small outlay. Attention is called in this connection that the railways are offering return passage at single fare rates.

MERCIER'S REPORT ON THE AQUEDUCT.

Paul E. Mercier, city engineer of Montreal, has submitted a report to the Montreal city controllers which replies to the aqueduct criticisms made last November by the ratepaying engineers of Montreal. Because it was written in English only, the report was not adopted by the controllers, who referred it back to Mr. Mercier with the request that it be translated into French. A Montreal newspaper, however, secured one of the advance copies of the report and has published liberal extracts from it. Assuming that the newspaper has quoted Mr. Mercier's report correctly, he apparently disagrees with the ratepaying engineers and flatly disputes their statements.

Mr. Mercier again intimates that the scheme has already been reported upon by other engineers, and he mentions other arguments that are differences of opinion rather than of facts, but a large part of his report is made up of quotations of facts and figures which are materially different from the facts and figures set forth in the ratepaying engineers' report. It should be easy for an impartial board to determine which set of facts and figures is correct and to find why the discrepancies occur.

As an example of the difference in facts between the two reports, it is noted that the ratepaying engineers say that the capacity of he headrace would be reduced to an average of about 7,000 h.p. in winter, even assuming that no frazil troubles be experienced. Mr. Mercier claims that water gauge readings extending over a period of nineteen years have been studied, and that the theoretical water horse-power was less than 13,000 for only one day.

In replying to the ratepaying engineers' argument that the bottom would be eroded, the retaining walls undermined and much other damage done if higher velocities of water were obtained, Mr. Mercier says that he does not think that a concrete floor would be so affected.

The ratepaying engineers state that about $5,200,000 has already been spent, including an allowance of $300,000 for boulevards, bridges, fencing and cleaning up, but no allowance for the claims of the Cook Construction Co. Mr. Mercier states that the amount of money that has been spent exclusive of filtration plant and pumping is $4,013,510. About $5,581,000 will be required to complete the work, says Mr. Mercier.

The ratepayers say that the minimum capital cost, based on the maximum safe capacity of the plant as designed, will be $1,515 per h.p.; Mr. Mercier says that the capital cost will be $737 per h.p. if all items are charged against the power development.

The minimum fixed charges and operating expenses will amount to $757,000 per annum, say the ratepayers; they will amount to $479,800, says Mr. Mercier.

The minimum fixed charges and operating expenses will be $108 per h.p. per annum, say the ratepaying engineers; this figure should be $40, says Mr. Mercier.

Mr. Mercier justifies an expenditure of $40 per h.p. per annum, whereas the city is now buying power for $20 (twenty hours) to $30 (twenty-four hours) per h.p. on contract from the private power companies, by asking who can state what the city would have to pay for electric energy in 1920, and by stating that the city cannot afford to gamble on the problematic future cost of power "when it can, at the actual market price, have its own water power and street lighting system at a lower cost or even at the same cost and be totally independent of any probable future trust."

It was pointed out in *The Canadian Egineer*, November 11th, 1915, that the power contract manager of the Montreal Light, Heat & Power Co. stated that his company is prepared to contract with the city for 10,000 h.p. (6,000 h.p. for pumping and 4,000 h.p. for lighting) at $25 for 24-hour power or $20 for 20-hour power.

The Canadian Egineer also stated in the above-mentioned issue that the city has the club that it could use on the private power companies of going to Quebec for a hydro-electric bill similar to Ontario's in case a fair contract with the companies should ever be found impossible.

Mr. Mercier suggests that a commission of two engineers and one business man be appointed to advise the controllers. We heartily concur in this suggestion. In the May 18th, 1916, issue of *The Canadian Engineer* suggested that an independent commission should be appointed consisting of "three qualified engineers, a banker who is conversant with the city's finances—Sir Frederick Williams-Taylor would be most acceptable—and, as chairman, some prominent Montreal business man who has the welfare of the city at heart and who has been efficient and successful in general business matters, but who has never 'mixed in' politically."

If Mr. Mercier's suggestion of two engineers and one business man be carried out by the controllers, we would strongly urge that Sir Frederick Williams-Taylor be appointed as the business man and chairman of the commission, and that the Montreal city council appoint one of the two engineers and the Canadian Society of Civil Engineers, the other.

PERSONAL.

H. OCCOMORE has been appointed chairman of the water commission of Guelph, Ont.

H. A. WOODS, M.Can.Soc.C.E., chief engineer, Grand Trunk Pacific Railway, Winnipeg, is away on a three months' vacation, and it is understood he will resign.

Dr. FRANK D. ADAMS, of McGill University, Montreal, was chosen president of the Geological Society of America at the organization's annual meeting held in Albany, N.Y., on December 28th.

H. E. WHITTENBERGER, general superintendent of the Ontario lines of the Grand Trunk Railway, suffered a painful accident at Black Rock recently when the brake lever on the rear of his private car flew around and struck him across the forehead.

Major ARTHUR E. DUBUC, A.M.Can.Soc.C.E., commanding the 22nd Battalion, is among the officers mentioned in the New Year's honor list. He received the D.S.O. Before going on active service he was the district engineer in Montreal for the Department of Public Works. He has been twice wounded.

Lieut. I. W. KLINGNER, of Toronto, who went overseas last February, going into the trenches in July with the 10th Canadian Engineers, has been awarded the Military Cross. He is a graduate of the School of Practical Science, and was connected with the C.P.R. construction department.

E. P. MATHEWSON, general manager of the British America Nickel Corporation, Limited, Royal Bank Building, Toronto, was awarded the gold medal of the Metallurgical Society of America for his achievements in metallurgy during the past year at the annual meeting of the society held in New York recently. Mr. Mathewson was educated at McGill University.

Temporary Major WILLIAM GRANT TYRRELL, son of Dr. J. B. Tyrrell, 546 Sherbourne Street, Toronto, has been mentioned in despatches for distinguished conduct at the front. He was in charge of railway construction work with the British Expeditionary Force in Egypt. He is a graduate of the R.M.C., Kingston, and belonged to the Royal Engineers. At one time he was in charge of the construction of military camps in the province of Quebec.

W. P. COOK, chairman, Public Utilities Commission, Port Arthur, Ont., and M. M. INGLIS, manager, Port Arthur Civic Railway, who attended the American Electric Railway Association's annual convention at Atlantic City recently, presented a report upon improvements in connection with the operation of street railways and their adaptability to Port Arthur's needs, at a meeting of the Port Arthur Public Utilities Commission recently.

A. K. GRIMMER, A.M.Can.Soc.C.E., of St. Andrews, N.B., has been given a commission in the Canadian Engineers. Lieut. Grimmer was graduated from the University of New Brunswick in 1904, and afterwards was city engineer of Fredericton for two years and also filled the same position at Medicine Hat for about five years. He was later engaged on the teaching staff of the University of Manitoba, Winnipeg, and just recently returned to St. Andrews, where he began private practice.

GEORGE HERBERT DAWSON, B.A.Sc., A.M. Can.Soc.C.E., surveyor-general of British Columbia, has resigned that position. Mr. Dawson, who was born in Quebec 50 years ago, went to the Pacific coast in 1889 after having been in the engineering department of the C.P.R. for three years on the Quebec division. He occupied the position of assistant city engineer in Vancouver for two years and later he was engaged in private practice in the same city for about ten years. He was appointed to the position he has just vacated in 1911. Since the start of the war Mr. Dawson has been given the appointment of western representative of the Imperial Munitions Board.

OBITUARY.

BERTRAM DAWSON, president of the Dickson Bridge Works Co., Campbellford, Ont., died on December 31st, at the age of 36 years.

Lieut. ARTHUR JAMES MOTYER, B.A., B.Sc., formerly engaged as an engineer by the Canadian Westinghouse Co., Hamilton, has been killed in action.

Lieut. E. GUY DUNSTAN, son of Mr. Kenneth J. Dunstan, manager of the Bell Telephone Company, Toronto, who was reported missing in July, is now stated to have been killed in action.

HUGH McCULLOCH, president of the Goldie & McCulloch Co., Limited, Galt, Ont., passed away on January 8th at the age of 61 years. He was born in Galt on September 7th, 1856, and was educated at the Whitby Grammar School and Upper Canada College, at the completion of which he served an apprenticeship in the shop of which his father, the late Mr. Hugh McCulloch, Sr., was then president. When the company was incorporated in 1891 and took over the business of the firm of Goldie & McCulloch, he was appointed secretary-treasurer, which position he held until he was elected vice-president in 1898, assuming the presidency on the death of his father in September, 1910. Mr. McCulloch was closely associated with various other manufacturing concerns in Galt, having been at the time of his death vice-president of the Galt Malleable Iron Co., Limited, also of the Galt Art Metal Co., Limited, and a director of the Galt Gas Light Company.

THOMAS MALCOLM, one of the best-known railway contractors in the Maritime Provinces, died recently at Campbellton, N.B., after a prolonged illness. He was born in New Brunswick in 1854, and was employed at an early age in the construction of the Intercolonial, while later on he was connected with the late John J. Macdonald on section B of the Canadian Pacific around Lake Superior. With Messrs. Boswell and Ross he built the Temiscouata Railway from River du Loup to the head of the St. John River. Some years ago Mr. Malcolm secured a charter for the construction of a line of railway from Campbellton, N.B., on the Bay de Chaleurs, to St. Leonards, on the St. John River, a distance of 110 miles, and for years he put his best energies into the construction of this enterprise, which he considered of vital interest to the province and to the Dominion, the road being completed several years ago under the name of the International. Some time since the International was leased by the Dominion Government with a right to purchase, and is to-day operated as a part of the Intercolonial. Mr. Malcolm was at one time interested with the late Hon. John Costigan in the Quebec & New Brunswick Railway, a line surveyed over about the same route as that followed to-day by the Grand Trunk Pacific from Chaudiere to Moncton, but the government took over that work.

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WATER DISTRIBUTION SYSTEM, OTTAWA

METHODS OF CONSTRUCTION USED IN CONNECTION WITH THE CAPITOL'S WATER SYSTEM—SOME DETAILS OF COST.

By L. McLAREN HUNTER,
City Engineer's Office, Ottawa, Ont.

IN 1913 a report was prepared by Messrs. R. S. and W. S. Lea, consulting engineers, Montreal, on the improvement of the water distribution system in the city of Ottawa. Since that year work has been proceeding on the day labor system, until the present date, when proposal No. 1 has been nearly completed at a cost of approximately $420,000.

In the September 10th, 1914, issue of *The Canadian Engineer* Messrs. Leas' report was dealt with at some length.

The consulting engineer's report compared Ottawa mains with those of Worcester, Springfield, Lynn, Cambridge and New Bedford, these cities being selected at random out of a class of about the same population as Ottawa. The Ottawa system compared very unfavorably with the five systems referred to, having a much smaller percentage of the large mains—also the smaller mains are mostly 5-inch, while in the other cities 6-inch has been adopted.

The new system of mains has been laid out so as not to conflict with the existing pavements in Ottawa, and provides for a 36-inch main feeder from the point of supply on Wellington Street (replacing one or both of the present 15-inch pipes on Commissioner Street), running along Bronson to Gloucester, and thence across the city on Gloucester, crossing the canal in two lines of 24-inch pipe at Laurier Avenue. The pipe will connect with the existing mains on Lyon Street and O'Connor Street, with a new 16-inch main along Elgin and Lisgar, and thence down Cartier Street. The Lyon Street main will be extended by an 18-inch line crossing the canal by the Bank Street Bridge and following along Bank Street to Billings Bridge. The present mains on Bronson Avenue and O'Connor Street are extended as shown, and cross connecting mains are also provided on Fourth Avenue and Woodlawn Place. The canal will be crossed by a 16-inch main from the end of Cartier Street to Cedar Street by an 18-inch one from opposite Third Avenue to Sterridge Street and by 18-inch pipes at Bank Street and Bronson Avenue. The section lying between the canal and Rideau River and between Bank Street and Hurdman Road is not completely subdivided. The consulting engineer, however, assumed a street layout in order to show approximately how this district should be taken care of.

Fig. 1.—Type of Three-way Hydrant used in New Distribution System.

The four parallel mains on Bronson, Lyon, O'Connor and Cartier are extended to the principal distributor for Wellington, Central and Capital Wards, and eventually for the section across the Rideau River.

The Gloucester 36-inch main, besides supplying the Lyon, O'Connor and Cartier mains, is the prinoipal feeder for St. George, By, Ottawa and Rideau Wards, also for Rockcliffe. After crossing the canal the Gloucester Street line divides at Nicholas Street into two branches, a 24-inch running down Nicholas to Gladstone. The other branch will be a 30-inch across Waller to Besserer, having two 16-inch connections to the Rideau Street main.

For the western part of the city a 30-inch main feeder will be constructed. This is to supply Dalhousie and Victoria Wards. Branches of 24, 20 and 16-inch will be taken off the 30-inch main.

With these mains constructed it will give a pressure of 80 lbs. for fire purposes.

Fig. No. 1 shows the style of three-way hydrants to be used throughout the city on new distribution mains. These are manufactured by Thos. Lawson and Sons, Ottawa.

In the construction of the 36-inch main on Gloucester Street the cast-iron pipes had an average weight of 6,500 lbs. and cost $38 per ton, or $10.31 per lin. ft.

The amount of lead used was 120 lbs. per joint, which cost approximately $10.

The trench was dug in loam, clay and hardpan, and as there was a sewer two feet from the trench this necessitated shoring, the method employed in doing this being shown in Fig. 2. The stringers were placed 3 ft. 6 in. apart, and were of 3-inch by 10-inch lumber. The sheeting used was 2-inch by 10-inch. These planks were strengthened by cross pieces every 6 ft. of 3-inch by 10-inch material.

The amount of lumber used per hundred feet of shoring was 1,925 lin. ft. 3-inch plank and 1,250 lin. ft.

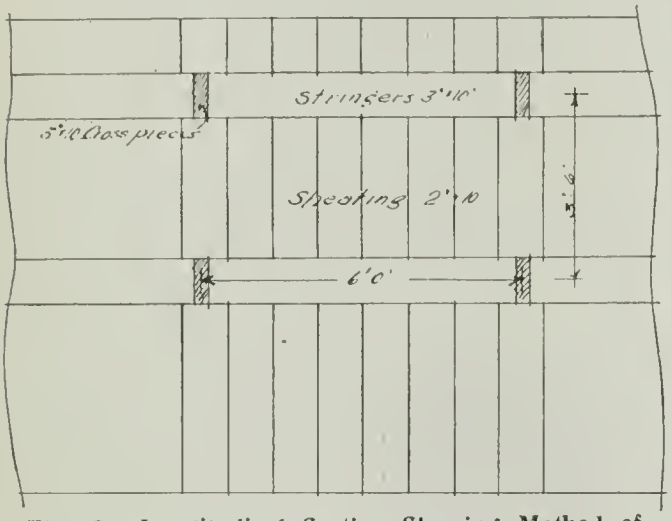


Fig. 2.—Longitudinal Section Showing Method of Shoring Trench.

2-inch plank. The greatest length of trench open at one time was 1,500 feet.

The 36-inch pipes were lowered as shown in photograph (Fig. 4). A traveller was erected running on two 4-inch trails, the pipe being lowered from the traveller by chain bocks supplied by the Herbert Morris Crane and Hoist Co., Toronto.

The joints were caulked as shown in Fig. 3. Hemp rope, "teased out," was packed as shown, and then lead was run into the joint. This was caulked with pneumatic hammers, run off a gasoline driver air-compressor (shown in Fig. 5). The average pressure at compressor

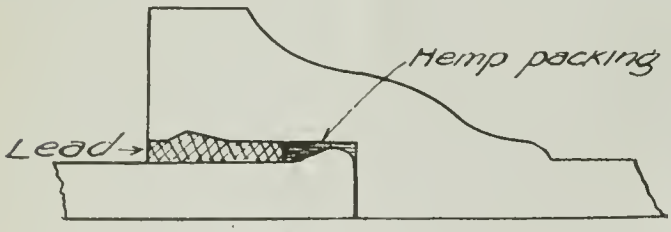


Fig. 3.—Detail of Pipe Joint.

was about 70 lbs. per square inch. Two to four hammers were run off this. Four men were kept constantly busy caulking on this main. Two men received $2.75 and two $3 per day. The engineer on the compressor was paid $3.30 per day.

The pipe-laying gang was made up of twelve men and a foreman, and the two excavating gangs had 40 men each, also a cart and from six to twelve teams.

The rates of pay for these gangs were: Foreman, $3.85; team, $5.30; cart, $2.70; watchman, $1.68; laborers, $2.52 for a nine-hour day.

The Gloucester Street main has been under construction for seventy-three days; 4,271 lin. ft. of pipe has been

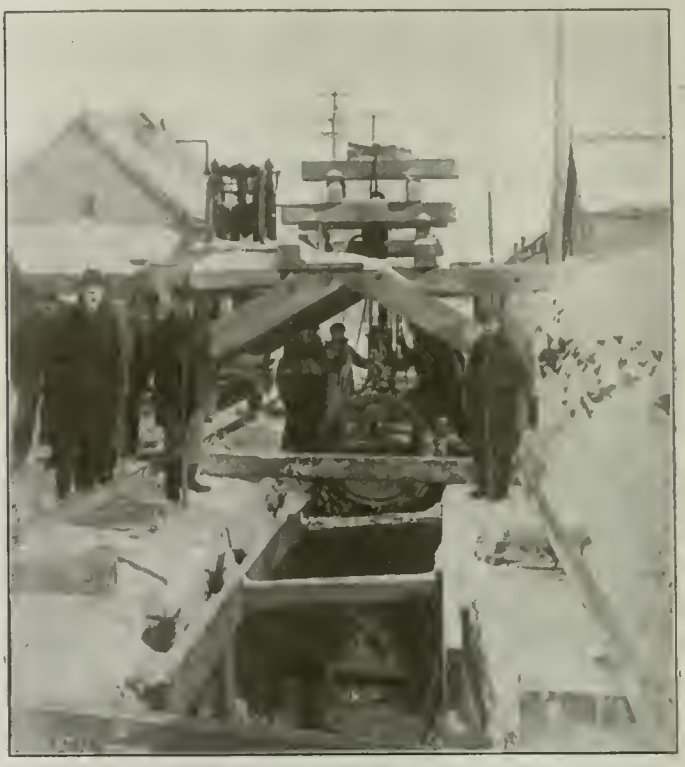


Fig. 4.—Showing 36-in. Water Main, Gloucester Street.

laid at a labor cost of $16,092.74; this includes excavating, filling, pipe-laying, shoring and pumping.

The cost per lin. ft. for labor only before frost set in was as follows:—

Excavating	$1.23
Shoring	.11
Pipe-laying	.57
Backfilling	.58
Removing earth	.38
Sundries	.20
	$3.07

After frost set in this cost increased to $3.76 per lin. ft. The pipes were supplied by the National Iron Works, Toronto.

The project has been carried out under the constant supervision of Andrew F. Macallum, commissioner of works, and W. E. MacDonald, resident engineer on the work.

Fig. 5.—Gasoline-Driven Air-Compressor.

LIMITATIONS OF FIELD AND LABORATORY WORK IN HIGHWAY ENGINEERING IN CIVIL ENGINEERING CURRICULA.*

By C. S. Farnham,
Sheffield Scientific School, Yale University, New Haven, Conn.

FIELD and laboratory courses in selected branches of applied science occupy an established position in the curriculum of every fully equipped school of civil engineering. They constitute a recognized channel through which instruction and training in civil engineering is conducted. No defence is necessary for the inclusion of field and laboratory courses in so practical a subject. It is pertinent, however, to consider whether some limitations may not exist in field and laboratory courses which render them less effective in broad civil engineering training and more particularly in that recent application of civil engineering known as highway engineering.

The educational value of field courses in surveying as well as the practical value is sometimes limited by unnecessary repetition. Several weeks may be spent in carrying on a survey in which the same methods are continually employed, or each student in a party may occupy the same position and go through the same operations for whole days at a time. This practice is sometimes defended on the ground that students thereby become skilful in surveying and consequently prove more valuable to their employers immediately after graduation, and on this account secure a firmer hold in the early stages of their professional life. The object of any educational process should be to develop the student's intellectual power and not primarily to make him skillful. Skill can be rapidly acquired after entering professional work but principles and methods can best be learned in college. The student's lack of skill in field work or in laboratory work is therefore a justifiable limitation.

Limitations upon field courses in surveying arise from the conditions of available time and place for conducting the work. The former custom of conducting field work upon the college campus during selected afternoons in term time has largely given place to continuous work for several weeks during the summer vacation at a camp maintained for the purpose. Advantages resulting are increased amount of work accomplished, freedom from interruptions which divert the student's attention from his work, more suitable ground for the conduct of certain kinds of work and the closer relations between students and instructors.

The suggestion is sometimes offered that special instruction in highway surveying should be given in a manner similar to that ordinarily followed for railroad surveying, or that less time be devoted to railroad surveying and a portion of the available time be devoted to a number of field exercises illustrating the particular kind of surveying which is employed in staking out a highway.

In railroad surveying courses to which more than ten or twelve days are devoted exclusively to the details connected with the location of a line of railroad it would appear that some repetition of work must occur and that part of the time could be employed to better advantage upon some other kind of work such as the survey of a short piece of highway. On the other hand, since the differences between the two kinds of surveying are those of detail and not of principle, it would seem unwise in view of the short time which some colleges give to railroad work to omit any essential operations connected with the location of a line of railroad for the sake of adding a few exercises in highway surveying. The engineering graduate who undertakes highway work usually enters the lower ranks of the organization of a highway department where opportunity is afforded him to learn the details of surveying through routine work.

Undergraduate laboratory courses in applied science in civil engineering include tests of materials used in construction, especially tension, compression and shear tests of steel and wood. Tests of simple structural joints, although less common, are sometimes made. Tests of masonry materials include the usual standard tests of cement with limited attention to fine and coarse aggregates and their proportioning in concrete. In view of the present standard quality of Portland cement certain tests formerly considered essential may well be omitted, thus allowing time for more careful examination of fine and coarse aggregates which engineers agree should often receive closer attention than the cement itself. Standards committees of the engineering societies perform a real service for educational as well as commercial testing laboratories by omitting unnecessary and non-essential tests which absorb the student's time and limit to that extent the effectiveness of his laboratory work.

The testing of concrete beams and slabs and waterproofing devices, together with detailed studies in proportioning, are valuable and important for the civil engineer preparing for highway work. Laboratory investigations of this character must be reserved for graduate study. Limitations which prevent their inclusion in undergraduate curricula are not so much insufficient appreciation of their value or meagre equipment as the lack of sufficient time available within the compass of a properly balanced undergraduate course.

Laboratory work in hydraulics is included in civil engineering curricula as generally as any course in experimental engineering. Field exercises in stream gauging not infrequently supplement the work of the laboratory. The usual undergraduate course in experimental hydraulics appears adequate for the purpose of the highway engineer.

The growing application of electricity to all fields of engineering is generally recognized and the inclusion of laboratory work in electricity in the curriculum for civil engineers is a logical development. Certain events have lately shown, if demonstration is necessary, that an engineer engaged exclusively in highway work may be called upon to supervise the maintenance of electrically operated draw bridges together with their illumination. Lack of time usually prevents the introduction of laboratory work in electricity into the undergraduate curriculum but the limitation can be overcome by graduate study.

Field and laboratory courses in geological studies are less common in civil engineering curricula than the subjects already considered. It is highly desirable that practical application of geology be made through field studies of soils and rocks which the civil engineer must consider in all work connected with excavation, drainage, foundations and selection of materials both for use in roads and in other structures. If this limitation exists it may be overcome, and in some civil engineering courses is overcome, through co-operation with the department of economic geology. In any event, field exercises in geology should be in charge of an instructor with sufficient experience in civil engineering to point out how knowledge of geological conditions may be of service to the civil

*Presented before Section D, Engineering, of the American Association for the Advancement of Science, New York. December 28, 1916.

engineer in the ways already mentioned. Instruction in a subject so vital to the civil engineer preparing for highway work should not be limited to textbook and classroom.

To meet the demand for men trained in special phases of highway work a few civil engineering departments have established laboratory courses for the testing of stone and brick for use in road building together with laboratory courses in the examination of bituminous materials. The value to the engineer of a knowledge of road building materials cannot be questioned, but the addition of specialized laboratory courses of this character to the undergraduate civil engineering curriculum is open to serious objections for several reasons. To make place for them, some subject of greater value must either be omitted or curtailed. A comparatively small percentage of the students in each class care to specialize in highway work. The greatest value resulting from a special course in testing lies in the student's ability to interpret the results obtained and to apply them in a practical manner to the choice of materials for definite purposes. To be able to judge of the fitness of materials upon the basis of laboratory tests requires highly specialized instruction and the expenditure of more time than a properly balanced undergraduate course can afford. Evidence is increasing that special applications of civil engineering should be reserved for graduate study when the limitations incident to undergraduate curricula can be avoided.

Modern textbooks on highway engineering devote considerable space to bituminous materials and the usual laboratory methods employed for their examination. In case the instructor in undergraduate work wishes his students to supplement their knowledge of bituminous materials by further study, the suggestion is offered that the department of industrial chemistry, if one exists, may be willing to co-operate in providing a course of lectures illustrated by apparatus and samples of materials.

In weighing the merits of laboratory courses which seem to be essential to the training of men who are to devote their energies to highway engineering, educators should not overlook the fact that studies of a different character, such as economics, accounting and the elements of business law may prove of more value in the development of future administrative officers of highway departments than a first-hand knowledge of testing materials.

In conclusion, it may be well to observe that members of this association may perform a real service by pointing out to a partially informed public the fact that our civil engineering schools are equipped to give students the fundamental training in civil engineering necessary for them to develop into capable highway engineers. Young men will avail themselves of the facilities which the schools offer as soon as positions in highway engineering are adequately compensated and the blighting limitations of residence qualifications and political influences are removed.

It is believed that the Cauvery dam, in the South of India, in the province of Mysore, when completed, will be one of the largest in the world. It will be 8,900 ft. long, and 124 ft. high. The total area covered by the lake that has been heaped up behind the dam approximates to about 43 square miles; while 17 villages have been submerged thereby, the population of which was nearly 10,000. The first stage of the reservoir, with the weir 80 ft. high, is expected to be completed by the end of the current year, the final stage being taken in hand later. It will be remembered that the original Cauvery power scheme was the first of its kind to be undertaken in India, transmitting current to the Kolar gold fields 90 miles away.

FILTER PLANT DESIGNED FOR ST. HYACINTHE.

IN an article on "Water Filtration Experience," which was published in *The Canadian Engineer*, issues of December 21st and 28th, 1916, H. G. Hunter, resident engineer at Montreal for the New York Continental Jewell Filtration Co., stated that he considered it better practice to house the entire area of the filter beds. He also referred to the desirability of making pipe galleries as accessible as possible.

Mr. Hunter has forwarded two tracings which illustrate these points. These are reproduced herewith. This plant has never been built, the drawings having been made merely as a suggestion for St. Hyacinthe, P.Q. Tenders for a plant at St. Hyacinthe will probably be asked for this spring.

Mr. Hunter states in a letter to *The Canadian Engineer* that this proposed plant for St. Hyacinthe is the best example known to him "of a plant with the filters located all to one side of the pipe gallery. This design also embodies the feature that I believe desirable in this climate, of covering the entire filter and operating room with the building; it also features the straight-flow coagulating basin without baffles.

"The pipe gallery in this plant is very accessible, it being possible to travel the length of the pipe gallery without interruption. The gallery also has windows which would give proper light and ventilation. The coagulated water from the coagulating basin is taken directly on to the back of the filters without being conveyed through long pipe lines or flumes, it being desirable to deliver the water to the filters with the least possible disturbance.

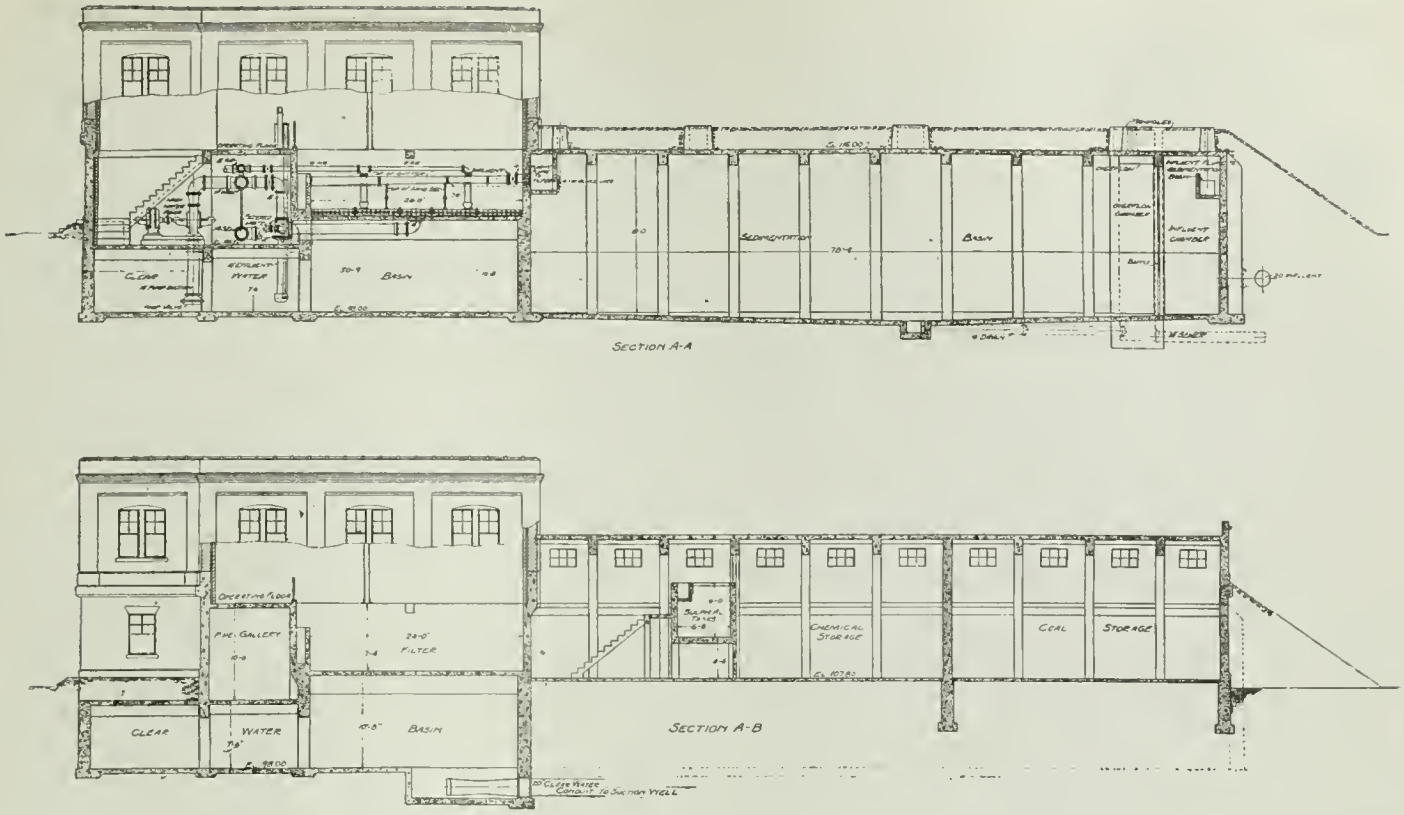
"Another point about this particular design is that it is truly a plan of a complete filtration plant; that is to say, it carries all of the accessories to a filter plant and provides space for them; notably, the wash water pump and air blower, the chemical storage room and chemical tanks. It does not provide a pumping station for low-lift pumping machinery. As stated in my paper, it is sometimes necessary to provide space for this, intending to convey the meaning that rightly the low-lift pumping station is work entirely aside from the design of a filter plant.

"In other words, all as above stated, I believe that this design for St. Hyacinthe covers all of the points mentioned in my paper as being desirable to feature in the design of a filtration plant."

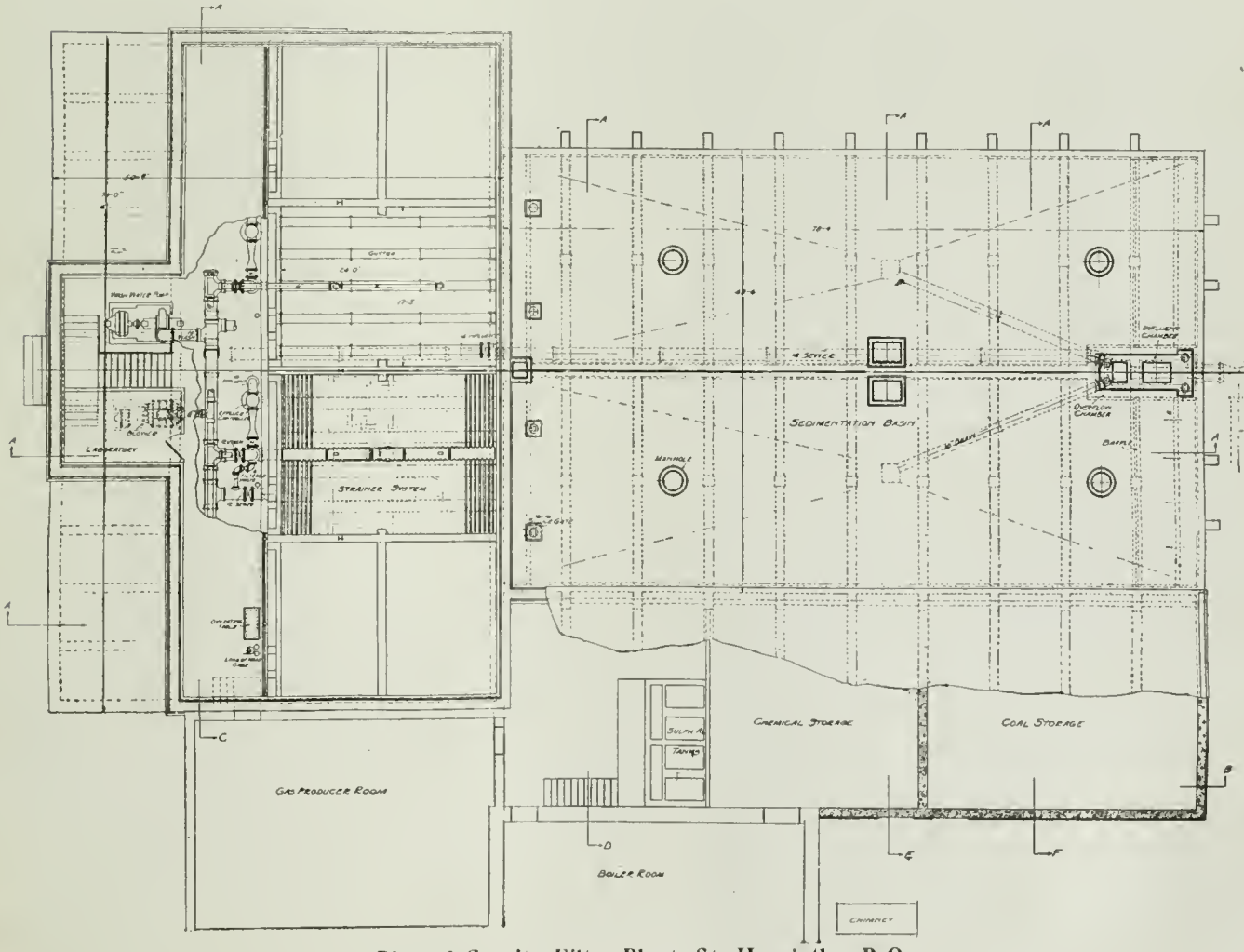
JAPANESE SHIPBUILDING.

The Japanese government is considering the question of reducing the national assistance extended to shipbuilding. The assistance hitherto given was afforded so opportunely that when the great war broke out in Europe and many ships were diverted from commercial to naval purposes by the belligerents, Japanese shipowners made great profits. The highly remunerative freight rates earned by ships have been even a greater stimulus to the growth of Japanese shipping than the government subsidies granted. This growth has, however, resulted in a heavy increase in the amount which the government is now called upon to pay shipbuilders. In 1914 these payments amounted to $815,000, in 1916 they were $1,561,000, and this year they are expected to be about $2,900,000. It is not surprising, accordingly, that the Japanese treasury is casting about for some relief.

Henry Ford, president of the Ford Motor Co., has been permitted to proceed with the construction of a $12,000,000 smelter on the Detroit River, near Detroit.



Sections Through Gravity Filter Plant, St. Hyacinthe, P.Q.



Plan of Gravity Filter Plant, St. Hyacinthe, P.Q.

VALUE OF A TRAINING IN THE HUMANITIES FOR ENGINEERS.*

By Nelson P. Lewis.

WHILE there are some conspicuous instances of engineers who have achieved marked success without the advantage of a degree from a technical school, the large majority of practicing engineers have had the benefit of a technical course before beginning their professional careers. In order to make any intelligent suggestions as to the subjects which should be included in such a course of study, it would be well to consider briefly the kind of work the engineer will be called upon to do. Engineering was formerly believed by the average citizen to be little more than a trade. It was thought that an engineer should be able to use surveying instruments and be able to compute land areas and the volume of a cut or fill or of a mass of masonry. He might be able to build a road, but in this respect he was held to differ very little from the average citizen, who appears to have been born with the conviction that he is as competent to build a road as to serve in Congress. The engineer's function was conceived to be the planning and carrying out of what others may have concluded to be necessary and expedient. Those who determined what was to be done seem to have felt it to be the duty of the engineer to do things when he was told, as he was told and because he was told. For a long time the engineer himself appeared to acquiesce in this conception of his functions. Whether or not a certain project was feasible or timely, whether the type of structure or the material which it was proposed to use was best adapted to the purpose, whether the enterprise would justify itself on economic grounds, whether the plan of financing it was sane and prudent, whether the terms of the franchise or concession, if such were involved, would insure adequate protection for the public and at the same time permit a fair return on the capital investment—such questions were not his concern. They would be settled by attorneys, capitalists or the public authorities. The engineer himself was not inclined to assume any responsibility for them; it was his duty to see that the general plans were honestly and expeditiously carried out. While he realized his responsibility for the stability of any structure erected under his direction he had little concern for anything but its physical stability, although he desired assurance that the funds were available to cover his fees or salary.

These were the conditions which prevailed within the memory of most of us, but they do not exist at the present time, except possibly in some branches of the public service, municipal, county, state and even federal. No financial concern engaged in floating bonds for private enterprises will now undertake to handle such securities until they have had a report from competent engineers as to the soundness of the project, including not only its engineering feasibility but its probable earning capacity and the market for its output, whether that be power, light or any manufactured product. Such reports, if they are to carry conviction, must not only be technically sound, but they must be orderly in arrangement, clear and concise in the presentation of facts, arguments and conclusions, and must bear upon their face evidence of the absolute confidence of the writer in the accuracy of his facts and deductions. Further than this, the engineer must frequently present verbal explanations and arguments to the promoters or to a board of directors before the enterprise is undertaken as well as during its progress, if he is charged with its execution. Many reports resulting from thorough and painstaking investigation fail of their purpose because the subject matter is not presented in an orderly manner and the conclusions are not clearly and concisely expressed. Often, too, when the engineer is called before a board of directors and asked for further information the impression which he makes is an unfavorable one, due, chiefly, to the use of poor English and the self-consciousness which comes from lack of practice in speaking.

The head of a large industrial corporation, who was also the chairman of a board of trustees of an engineering school and was urging the broadening of engineering education, put the case in this way:

"We can get plenty of men who are technically competent, who are careful and thorough in their investigations, whose conclusions we know to be sound, but who cannot make a favorable impression before a board of directors. We can get plenty of lawyers, who, after being coached by our engineers, can glibly and even convincingly talk to this same board of directors until some question is asked which has not been covered in the process of coaching, when they, too, will flounder about. If we can secure a man who possesses the conscientious thoroughness and accuracy of the engineer and also has the facility of expression and persuasiveness of the lawyer, what is a salary of $25,000 or $30,000 to us for such a man?"

He, therefore, urged that this particular school, instead of trying to turn out a large number of $2,000 to $5,000 men, give to the profession a limited number of $25,000 to $30,000 men.

What kind of studies are best calculated to fit a man for such a professional career? Let us say that the purpose of his training should be to insure:

(*a*) Honesty and accuracy in his reasoning.

(*b*) The habit of thoroughly testing his conclusions in order that they may be not only the logical, but the inevitable, result of his premises.

(*c*) Clearness and simplicity in his presentation of both premises and conclusion.

(*d*) Orderly and logical arrangement of both, so that they may readily be followed by those to whom they are addressed.

Personal honesty and high professional ideals are, of course, essential to true success in any occupation, but the course of training in these subjects should begin before a boy is born and we are considering only his professional training after the high school period.

The study of mathematics should induce accuracy in thought and work. An error cannot be tolerated and will inevitably be discovered in the solution of a mathematical problem which, if properly checked, will prove itself. If not so checked and its accuracy proven, the perpetrator of a mistake cannot escape its consequences. Such reasoning, however, is conducted through the medium of formulæ and equations which are not understood by the layman for whose benefit they must be converted into ordinary language. If we are to insist, as it will doubtless be admitted that we should, that engineering is one of the learned professions, ranking in dignity with law, medicine and theology, we may also insist upon the desirability of an equally thorough foundation upon which engineering training is to be based. It will be futile to urge that en-

*Paper presented before Section D, Engineering, of the American Association for the Advancement of Science, New York, N.Y., December 28, 1916.

gineering degrees should be given only as the result of a post-graduate course open exclusively to those presenting arts degrees. While the increasing number of men holding such degrees who come to our best engineering schools is most encouraging, it will be unwise to insist upon this as an entrance requirement. To do so would exclude many earnest young men who possess the natural ability, ambition and industry to achieve success in whatever they undertake, but who have neither the means nor the time for both the arts and engineering courses. What we may properly insist upon is that the courses in our engineering schools be liberalized by the introduction of some culture studies. Dr. J. A. L. Waddell, who has been insistent in urging the broadening of engineering education, said in an address to the Engineers' Society of Western Pennsylvania:

"Technical teachers are beginning to awaken to an appreciation of the fact that it has become absolutely essential to instruct their students in other lines than mathematics and technics in order properly to fit them for their life's work and that American engineering courses will have to be broadened so as to provide thorough instruction in economics, history, oratory, logic, business and other studies of a non-technical nature. Without a good grounding in such lines the engineer of the future will continue to be a narrow technist—unappreciated by the community and insufficiently compensated for his labors."

I am not taking too literally the subject assigned to me and insisting upon a study of "the humanities." The term is an old one and its meaning is not quite clear. The Century Dictionary defines the humanities as "including learning or literature of a merely human or secular kind as opposed to divinity, and generally the several branches of such literatures as philology, grammar, rhetoric, poetry, the study of the ancient classics and the like." Professor G. P. Marsh notes that the conviction of the value of these studies as a moral and intellectual discipline has led scholars almost universally to ascribe the origin of this appellation to a sense of their refining, elevating and humanizing influence. He expresses the belief, however, that it is an erroneous etymology, holding that they were so called in distinction from divinity, the two studies of philology and theology then completing the circle of scholastic knowledge which at the period of the introduction of the phrase scarcely included any branch of physical science. May I not then take sufficient liberty with my subject to insist that engineering courses must be enriched by the introduction of culture studies?

It is quite probable that familiarity with the classics, supplemented by a thorough course in one's own language, will greatly enrich one's vocabulary, but all of this is not needed to enable an engineer to write an intelligent report or to address a board of directors. It is not necessary that a report dealing with an engineering subject should be expressed in the language of a Howells or a James, nor will its force and that of its conclusions be lessened by the occasional use of a split infinitive or through the employment of a phrase that might give pain to some purists. It will, however, be much more forceful if expressed in simple but virile language, the habitual use of which can be acquired only by the reading of the best literature.

Many of the so-called colleges of liberal arts no longer insist upon Greek and require little Latin on the part of candidates for admission, while Latin is not carried beyond the freshman year except as an elective, although the enforcement of the group system, with one major subject and carefully balanced electives, is calculated to produce a well-educated man, if not a scholar in the old sense. Why should not our engineering schools so modify their curricula as to insist upon a major group of engineering subjects, supplemented by a thorough course in the English language and literature, a good training in, not a smattering of, one other modern language, and courses in history, economics and the law of contracts? But the technical school men will say, we would not have time to do this unless we shorten or omit some of the courses which we believe to be essential to an engineering education or add another year to our course. Then let them adopt one or the other of these alternatives, and it is quite probable that the records of their graduates would reflect greater credit upon these schools than they have in the past. A number of specific instances could be given of men whose professional training has been along entirely different lines and who have attained conspicuous success as engineers. While these cases may be exceptional, they are sufficiently numerous to justify a reference to them and even to support the plea for liberalizing engineering training.

The six-year course leading to both the arts and engineering degrees which has been adopted by a number of our universities is most encouraging evidence that engineering is coming to be considered one of the learned professions, and yet for those who can afford the time and money the ideal plan would be to pursue their culture studies in one of the smaller colleges which have not yet gone to an extreme in the adoption of the elective system. A young man will be more likely to attain real culture in such an institution, his interests will be broadened, his life friendships will be among men of various professions and occupations and he will have a better opportunity to find himself and make a wise choice of a profession if that choice may be deferred until the latter half of his college course. The influences and associations of the college campus are distinctly humanizing and, even though he may attach as much importance to athletics as to scholarship, he will have laid an admirable foundation upon which the superstructure of his professional education may be reared. The writer realizes that, while this plan may be ideal, it is beyond the reach of a great majority of those who wish to enter the engineering profession.

Next to this in its advantages may be placed the six years' course leading to the arts and engineering degrees, but even this is too long in most cases and the greatest number of engineering students will continue to begin their professional courses immediately after finishing their secondary school work.

It is unfair to these young men, it is unfair to the engineering profession, to confine their further education wholly to strictly technical courses. Extend these courses to five years, if necessary, in order to introduce the liberal studies which have been referred to, giving credit to those who present degrees from reputable colleges, so that they may complete the strictly technical work of the curriculum in four or even three years. In other words, it is time that those who are responsible for the training of engineers realized that they are fitting men for one of the learned professions and that this cannot properly be done unless the curriculum is humanized.

Eight million dollars' worth of street extensions, widenings and connections are in prospect for the West Side district of Chicago as a result of the action taken by the Chicago Plan Commission. The work will make the first unfolding of the Plan of Chicago in its aim for better traffic conditions throughout the West Side.

NITROGEN FROM SEWAGE.*

By Dr. S. Rideal, F.I.C., F.C.S.

MUCH progress has been made in recent years, and many of us remember the explosions which took place in some of the closed septic tanks in the early days when they were of no military importance.

These gases are derived from the anaerobic decomposition of the organic matter in the sludge, and have hitherto hardly been utilized. They consist largely of methane, and may be 2 or 3 per cent. of the volume of the sewage from which they are derived. When septic change does not take place, the equivalent organic matter remains in the sludge, and thus increases its calorific value; when formed in Imhoff or Travis tanks they are also combustible. Analyses of the gases from the Atlanta Imhoff tanks have shown 8 per cent. of hydrogen and over 80 per cent. of methane. When sludge is activated with air these gases are not formed or are lost.

Cavel, in 1912, in Paris, studied the formation of gas from the sludge. He mixed the dried sludge with 20 per cent. of coke and obtained 81.7 cubic metres of producer gas having 3,500 calories per cubic metre. In his experiments he used the gas so formed for drying fresh portions of the sludge, and calculated that from Paris and the Seine Department 300 tons of dry sludge could be obtained per day, giving 24,500 cubic metres of gas, worth 447,000 francs per annum.

To utilize these gases for war material, the Hensler engine seems best adapted for further study. In it the explosion takes place in excess of air, and the oxides of nitrogen formed, as in an arc lamp, are rapidly removed to a cooling chamber to prevent their decomposition.

When absorbed in a water tower weak nitrogen acids are produced without the employment of sulphuric acid, and thus a direct fixation of atmospheric nitrogen to nitric acid could be effected by the waste gases from our sewage works. I will not venture, from the data I have given you, to make a calculation, as in the case of glycerine, of the metric tons of nitrate that could be obtained in this way, as, fortunately, in this country at any rate, fuel for gas producers will outlast this war, but in beleaguered Bucharest, after a prolonged siege, such a device might be turned to advantage.

Utilization of Sewage Nitrogen.—I must now turn to the most important part of my subject, viz., the conversion of sewage nitrogen into available nitric acid.

The utilization of sewage nitrogen is no new problem. Sir William Crookes, many years ago, said: "We have the startling fact that in the United Kingdom we are content to hurry down our drains fixed nitrogen to the amount of no less than £16,000,000 per annum. This unspeakable waste continues, and no effective and universal method is yet contrived of converting sewage into coin." At the time of this calculation nitrate of soda was worth £7 10s. per ton, so that nitrogen even then was over £50 per ton. Mr. Ashton referred to this waste in his interesting paper on sugar from sewage in 1910 before the Manchester branch of your association. It would take me too far afield to discuss whether in war-time we ought to import nitrogen as wheat or as nitre, as the taxation of land values and the problems of transport and freights must be foreign to the business of this meeting.

I can give you some figures which show the enormity of the problem which you can better appreciate.

One hundred thousand persons produce on the average 90 grms. per person per day of fæces and 1,170 grms. of urine, equivalent to 3,300 tons per annum of solids and 43,000 tons of urine. The nitrogen in fæces is 1 per cent., in the urine .66 per cent. We have, therefore, 33 tons of organic nitrogen in the solid fæces and 258 tons in the urine.

Our military camps could furnish 11,640 tons per annum and the civil population 116,400 tons if all the nitrogen could be converted.

We may get a total nitrogen figure direct from sewage analyses. A fair figure to take is 5 parts per 100,000, or 5 lbs. per 10,000 gallons at 40 gallons per head, or 250 persons, so that a military camp of 4,000,000 could furnish 80,000 lbs., or 40 tons a day, or 14,600 tons per annum.

It is, of course, a war secret how much nitric nitrogen is required by the belligerents per annum, but we know that the Chili exports have now all been diverted from Germany, and that in the past we have relied on this source, while the Central Powers have had to improvise their raw material.

The Badische Anilin and Soda Fabrik have published their output of sulphate of ammonia by their Haber process of synthetic production from atmospheric nitrogen as equal to 300,000 tons, which is equivalent to 62,000 tons of nitrogen per annum.

This synthetic sulphate of ammonia in Germany is now being converted into nitric acid by the Ostwald process to replace the Chili nitre, which the Allies have commandeered. My figures show that in sewage we have twice as much nitrogen available, but not yet utilized, already in combination, either as ammonia or in organic form.

Recovery of Ammonia.—How can this ammonia be removed from our sewage? It is not like extracting gold from sea-water, as we have all of us smelt it at our works, and many of us have determined the amount in our laboratories.

I suggest the recovery of the free ammonia by one of two simple methods: (1) Its removal by heat; (2) its removal by air.

(1) The Removal of Ammonia from Sewage by Heat.—It is common knowledge that heat exchangers can be now designed to work with a very small loss of energy, and that the removal of the free ammonia from a tank effluent is, therefore, not an impossible task. The addition of lime to ensure the freeing of any ammonium salt may be necessary, and the effluent, after being "deammoniated," could be further purified by filtration or land treatment.

(2) The Removal by Air.—Sewage treatment by aeration and activation is now one of the recognized methods, and has been tried in many places in this country and America. The colloidal and suspended matters form a sludge which is especially rich in nitrogen, and the effluent contains nitrates before filtration. It would seem that the air treatment thus brings about a rapid evolution of carbonic acid and nitrification, so that the escaping gases will not, under ordinary conditions, contain any ammonia.

When, however, air is aspirated through an ordinary sewage, the ammonia is removed by the air, and I suggest that if the "activation" be carried out in presence of lime, nitrification will not be so complete and some of the ammonia will be present in the escaping gases.

*Abstract of paper read before the Association of Managers of Sewage Disposal Works.

CAUSES OF CRACKS IN CEMENT CONCRETE PAVEMENTS.*

By A. T. Goldbeck.†

IT is the intent of this paper to treat merely of the causes of cracking of concrete pavements in the light of our present knowledge of the subject. There are many phases of the question of cracking that might properly be brought out in a discussion, such as the effect of cracking on the life of the road, the expense of and best methods of the maintenance of cracks, and many other allied questions. All of these, however, have been avoided and an effort has been made to treat only that phase of the subject suggested in the title.

When the internal stress in a material reaches the ultimate strength, failure ensues and manifests itself in various ways. In a brittle material like concrete, a crack indicates that the ultimate internal resisting stress, whether it is tension, compression, or shear, has been exceeded and, therefore, in order to analyze the cause of cracks in a concrete pavement, we must first discover the cause of the high internal stresses existing at rupture. This is a difficult task as the internal stresses in concrete and reinforced concrete pavements are very complex and may be caused by a number of different phenomena acting simultaneously.

A concrete road slab is attacked by many forces which slide it, in part or as a whole, along its sub-base; which bend it and warp it; which subject it to impact and shear, and may even act within its interior to exert a disrupting effect. It is little wonder that concrete roads crack, since, due to the lack of experimental data, they are constructed without sufficient knowledge of the forces to which they will be subjected.

Let the life of a slab in the road be traced from the day it is poured in order that the complexity of stresses to which it is subjected may be studied. For about ten days or two weeks after the slab is laid and while the concrete is hardening, it is the practice, for several reasons, to keep the surface thoroughly wet. In the first place, water is necessary to hydrate the more inactive particles of cement, and, moreover, it has been discovered that as long as concrete is kept wet, its length changes but very little, provided the temperature remains constant. Any slight change that does take place due to moisture is favorable to the integrity of the concrete, because moisture expands concrete, and tends to produce small compressive stresses, owing to the frictional resistance at the sub-base against this expansive movement. Should the temperature rise during this initial period, additional expansion will result with increased compressive stress in the concrete. Even this combined compressive stress, however, is seldom likely to be very large during the initial stages of hardening, and may be neglected, as the concrete is generally sufficiently strong in compression to withstand the small forces then being exerted. Should there occur a large decrease in temperature during this initial period, the concrete will contract, causing it to move with respect to its sub-base. The forces of friction thereby developed produce tension, and as green concrete is weak in tension, a decrease in temperature, when the pavement is only a few days old, may cause cracks.

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Suppose the pavement survives this initial period without mishap and is thrown open to traffic. Immediately it begins to dry out and due to this cause it starts to shrink. The friction forces at the base immediately resist this shrinkage and the result is tension in the concrete. If the tension is too great the concrete cracks where the tensile strength of the concrete has been exceeded. As the seasons of the year succeed one another, the slab is alternately wetted and dried, and in addition, subjected to a wide range of temperatures, being thus kept in constant motion over its sub-base. The forces of friction are therefore in constant action resisting this motion, and thus cause stresses, now tensile, now compressive, to exist in the concrete. Should the forces of friction be sufficiently great, the resistance of the concrete is overcome and it fails, either in tension or compression, with one of two results, the concrete is cracked, or else bulged up or crushed. Sometimes moisture and temperature aid one another, and sometimes they counteract one another, but their activities are never ended during the existence of the road. Naturally, as friction can best be developed along the length of the road, temperature changes and moisture are promotive of transverse cracks rather than longitudinal cracks.

In addition to direct compressive and tensile stresses, road slabs are subjected to bending, due to the loads of traffic and more likely to unequal settlement of the sub-base, caused by lack of homogeneity. Ununiform reaction between the slab and the sub-base due to frost may also produce cracking, the slab then being supported in some spots and not in others, thereby creating large tensile stress in bending. Frost action is more likely to cause longitudinal cracks than transverse cracks. The expanding and shrinking of the sub-base, due to varying moisture content, is also promotive of bending stresses and consequent cracking in the concrete.

In a general way, the foregoing discussion treats of some of the causes of cracking of concrete pavements, and these causes can best be classified as follows:

1. Expansion and contraction. (*a*) Change in temperature; (*b*) change in moisture content.

2. Ununiform bearing under the slab. (*a*) Frost action; (*b*) lack of homogeneity in sub-base; (*c*) moisture expansion and shrinkage of the sub-base.

3. Excessive bending stress due to heavy loads and impact.

These causes will be considered in detail so far as our present knowledge will permit.

Expansion and Contraction.—(*a*) Change in temperature: It has been well established by several investigators that concrete expands and contracts as the temperature changes, and the amount of movement equals 0.0000055 inches per inch of length. If a concrete road is built in the summer season when the temperature is 90° F. and the temperature in the following winter falls to 0° F., the concrete must contract an amount equal to $0.0000055 \times 90 = 0.00495$ inches per inch of length. This contraction could do no harm if it were not for the resistance offered by friction between the sub-base and the slab. When the concrete contracts, the friction at the base resists the contraction and the amount of tension produced in the concrete is dependent on the amount of friction acting. Friction at the base varies with the kind of base and the degree of roughness and tests recently made by the author throw some light on the amount of friction that can act at the sub-base when the slab expands and contracts.

Friction at the Sub-base.—The tests referred to above were made by sliding 2-ft. x 6-ft. x 6-in. concrete slabs along previously prepared sub-bases. The sliding force was applied by means of a long lever and the magnitude of the force was measured with a carefully calibrated dynamometer. The amount of movement of the slab was read with a Berry strain gauge while the load increased slowly and steadily.

As the load was applied, the slabs seemed to move very slightly, even at the first application, except where a sub-base of large broken stone was used. In this instance a high load was necessary to start the slab in motion after which it required no more load than some of the other bases. Apparently there does not exist a constant value for the coefficient of friction, for the greater the displacement the greater the force of friction becomes.

The values of the frictional resistance offered at various displacements are given in the table at the foot of page.

When the slab on the loam base had been slid 0.035 inch, the then existing load of 1,600 pounds was released to zero, and the slab recovered 0.017 inch of its motion. From this recovery behavior it is seen that the sub-base acts in a somewhat elastic manner, and some of the resistance offered to the expansion and contraction of the slab must be that necessary to deform the sub-base. The material of the sub-base is far from being perfectly elastic and it must therefore gradually yield under a slowly applied load such as would obtain in the expansion and contraction of concrete pavements. Hence it is not at all reasonable to assume that the maximum friction shown in the tests described actually exists in concrete pavements, even where their movement is large. The above tests were made in periods of about 10 minutes each, while the corresponding movements in the road might take days.

Moisture Shrinkage.—When a specimen of concrete is permitted to harden under continually moist conditions, it expands slightly; on the other hand shrinkage takes place when it hardens in a dry atmosphere. The amounts of expansion and contraction are dependent to some extent on the richness of the mixture and also on the thoroughness of the drying. For instance, consider the experiments on two specimens, 1:2:4 and 1:3:6 concrete, of very wet and very dry consistency. Several days after hardening they were immersed in water and extensometer readings were made on them at frequent intervals. As long as they were wet they remained expanded, with the maximum expansion of 0.0001 inch per inch of length. After 6 months they were removed from the water and allowed to dry out in the warm dry air of the laboratory, when they immediately began to contract, reaching an ultimate contraction of 0.0008 inch per inch of length. It must be emphasized, however, that these specimens became exceedingly dry in a very short time after their removal to the air of the laboratory and probably very much dryer than they could ever become in the road. When specimens are subjected to the every-day wet and dry weather conditions, they do not change in length very much due to change in moisture content, because their moisture content does not vary greatly under such conditions. Concrete in the road may, under exceptional conditions, be made to suffer extreme drying, but it is very probable that most concrete roads absorb much water by capillarity from the damp or wet underlying sub-base, and moreover, the water that is absorbed during a period of wet weather does not completely evaporate between successive spells of wet weather. However, there is sufficient evaporation from the surface to cause some shrinkage of concrete in the road as evidenced by the formation of cracks when road slabs are allowed to dry out too quickly. The maximum amount of shrinkage that concrete can reach is 0.0008 inch per inch of length, but it is probable that, in general, the moisture shrinkage of concrete road slabs does not exceed more than 0.0004 inch.

Combined Moisture and Temperature Changes.—It is evident, therefore, that both moisture and temperature act to cause creeping of the slab in the road, and it must be realized that the relative magnitude of these two effects depends on the range of temperature, on the rainfall, and on the drainage of the sub-base. In an exceptionally well-drained sub-base and in a dry climate, the moisture shrinkage of the concrete will be large, and will add to the contraction due to changes of temperature. This shrinkage may amount to 0.0004 inch per inch of length and if there is a decrease in temperature of 100° F. there will be an additional shrinkage of 100 × 0.0000055 = 0.00055 inch or a total shrinkage of 0.00095, or, roughly, 0.001 inch for each inch of length. On the other hand there may be much moisture in the sub-base which will keep the concrete expanded 0.0001 and the net shrinkage will then equal 0.00055 minus 0.0001 or only 0.00045 inch.

It has been pointed out that the sliding of concrete along the sub-base develops frictional resistance of considerable magnitude, and when the tension developed in the concrete due to the forces of friction exceeds the tensile strength of the concrete a crack must form. Let the coefficient of friction be equal to 1.0, and assume the tensile strength of the concrete to be 150 pounds per square inch. Let L equal the distance between cracks, then, in a slab 12 inches wide and 6 inches thick, the stress at rupture equals 72 square inches × 150 pounds, equals 10,800 pounds. This stress must be supplied by the forces of friction acting over the distance between cracks, or $fLw = 72$ square inches × 150 pounds per square inch where w equals the weight of the concrete per linear foot. This equation reduced to $1.0L72 = 72 \times 150$ or $L = 150$, the distance between cracks. If $f = 2.0$, then $L = 75$

Frictional Resistance of Concrete on Various Sub-bases.

Kind of base.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.	Movement.	Force.	Coefficient.
Level clay	0.001	480	0.55	0.01	1,130	1.3	0.05	1,800	2.07
Uneven clay	0.001	500	0.57	0.01	1,120	1.29	0.05	1,800	2.07
Loam	0.001	300	0.34	0.01	1,030	1.18	0.05	1,800	2.07
Level sand	0.001	600	0.69	0.01	1,080	1.24	0.05	1,200	1.38
¾-inch gravel	0.001	450	0.52	0.01	960	1.10	0.05	1,100	1.26
¾-inch broken stone	0.001	380	0.44	0.01	800	0.92	0.05	950	1.09
3-inch broken stone	0.001	1,060	1.84	0.01	1,550	1.78	0.05	1,900	2.18

feet, so that the greater the friction the closer will be the spacing between cracks.

The above calculations indicate the advisability of forming the sub-base as smoothly as possible. Of course, the tensile strength of the concrete can not obtain unless the concrete is stretched sufficiently. When 150 pounds per square inch exists in the concrete, each inch is stretched 150/3,000,000 = 0.00005 inch and it has been shown that the shrinkage due to moisture and temperature change may amount to 0.00095 inch, far in excess of the amount required to cause rupture.

The foregoing considerations are based on mature concrete. When the concrete is only a few days old, the tensile strength is very small indeed, and the modulus of elasticity is likewise low. When but two days old the tensile strength may be as low as 50 pounds per square inch, and the modulus of elasticity in tension may be only 1,000,000. The stretch required to produce rupture is then 50/1,000,000 = 0.00005. This amount of shrinkage could readily be caused by slight drying out or by a decrease in temperature of only 0.00005/0.0000055 = approximately 9 degrees F. A comparatively small decrease in temperature may thus produce cracking in the concrete pavement. If the tensile strength at two days is only 50 pounds per square inch, the distance between cracks, when the concrete contracts sufficiently, will be smaller than it is if the concrete cracks at a later period when it has attained higher strength. Assuming the same values for friction and weight of concrete as before we have

$$fLw = 50 \times 72, \text{ or}$$
$$1.0 \times L \times 72 = 50 \times 72$$
$$L = 50$$

If the coefficient of friction equals 2.0. There may be times, due to a big fall in temperature just after the concrete has hardened and the tensile strength is exceedingly low, when the cracks will be much closer together than the above figures show. There are often cases when the sub-base contains projections and depressions that greatly add to the frictional resistance offered to sliding and such a sub-base aids in the production of cracks at close intervals.

Field Measurements.—In order to gain some idea of the actual changes in length which takes place in the road slab in place, many field measurements have been made by the Office of Public Roads and Rural Engineering. In general, the expansions and contractions were found to follow closely the temperature changes.

Uniform Bearing Under the Slab.—Irrespective of what may cause lack of uniformity of bearing under the slab, let it be assumed that due to some cause this unequal support exists. As an exaggerated case, let it be assumed that the slab is largely supported at its two sides, and acts therefore as a single beam. Assume a 16-foot roadway 6 inches thick. The fibre stress in the section of greatest bending moment then equals $S = \frac{Mc}{I} = \frac{WL}{8} \times \frac{6}{bd^2} = \frac{72 \times 16 \times 16 \times 12}{8} \times \frac{6}{12 \times 36} = 384$ pounds per square inch. This value is close to that of the modulus of rupture of the kind of concrete used in road construction. The dead weight of the pavement alone is thus almost sufficient to cause cracking if the slab is afforded improper support. The same condition would hold if the pavement were unsupported at the sides but fully supported at the centre. Add the weight and impact of traffic to increase the bending moment due to dead load and it will be readily seen that under the right conditions of improper sub-base support, a longitudinal crack is likely to form.

Before considering these conditions producing improper support, let the amount of deflection of the slab at rupture be figured. In a simple beam uniformly loaded, the deflection at the centre $D = \frac{5}{384} \frac{WL^3}{EI}$. Assuming a 6-inch slab, 16 feet wide and supported at its sides, the deflection under its own weight equals $\frac{5}{384} 72 \times 16 \frac{(16 \times 12)^3}{3{,}000{,}000} \times \frac{12 \times 6^3}{12} = 0.164$ inches. The slow yielding or "flow" of concrete acts to increase this figure and might even treble it, thereby making the possible deflection as much as 0.5 inch when the crack forms.

Regarding the causes of unequal bearing, nothing very definite may be said. It is generally recognized that unequal compaction of the sub-base due to lack of homogeneity and to uniform rolling may cause more settlement in some spots than in others, and many sub-bases built of old Telford or macadam roads are very likely to lack uniformity. Again, the well-known expansive effect of freezing can very readily act with different intensity in different parts of the road, thereby causing more than enough rise to produce cracking. The shrinkage of soils when they dry out and their swelling when moistened is an occurrence of every-day observation, and it is quite possible that the shrinkage of the foundation away from the concrete is sufficient in places to cause great bending stress with the formation of cracks in the concrete. The raising of the sub-base in spots need not be more than 0.2 inch to cause cracking and the expansive effect of the frost and the swelling and shrinkage effect of moisture on the sub-base may be considerably more than this. The writer now has some experiments in progress to show the effect of freezing and moisture on the vertical movement of the road.

Impact of Traffic.—The weight of traffic serves but to accentuate the stresses due to the other physical causes. Heavy loads on a thin slab or where the bearing is ununiform may cause either transverse or longitudinal cracks and when these loads are applied suddenly or with impact, as is the case with the modern heavy truck and steel-tired trailer, these loads will aid the other causes of cracking, although they may not be severe enough to be effective themselves. Traffic, however, often breaks off the corners of slabs, the load then being concentrated near a point having poor bearing.

In conclusion, it must be emphasized that great effort should be exerted to protect the concrete during its initial stages of hardening. Do not mix it any wetter than necessary to obtain smooth yet economical construction. Protect it from sudden decrease in temperature and keep it wet for at least two weeks in order to prevent undue shrinkage while the concrete is green. Much attention should be given the sub-base, for, as has been pointed out, the friction at the base causes transverse cracks. This friction may be greatly reduced by proper care in the preparation of the sub-base and in this way the cracks may be widely distributed if not entirely eliminated. In addition, provide proper drainage to keep the sub-base as dry as possible, so that the effect of frost and the settlement due to moisture may be eliminated. Finally, design the slab as to thickness to carry the loads it is supposed to carry, irrespective of whether the sub-base offers uniform bearing or not.

TEST OF A FOUR-INCH SINGLE-STAGE TURBINE PUMP.

By J. H. Parkin, University of Toronto.

ACTUAL performance data or test results of small, low-head centrifugal pumps (under 6-in. and 50 ft. head) are seldom published, and little is available for reference compared with the large amount on pumps of larger size. This condition is primarily due no doubt to monetary considerations. Large pumps have large initial and operating costs, and generally are of more or less special design to meet separate requirements. Since the quantities involved are large, a slight difference in the design or operation may mean a considerable saving, either in initial or operating cost, and carefully conducted acceptance tests are, therefore, run, the results of which later find their way into the technical press.

On the other hand, small-size pumps are of relatively small initial and operating cost and are generally manufactured in stock sizes. From curves and data supplied by the manufacturer the stock size is chosen coming nearest to requirements. The nice differences considered in the case of larger pumps do not enter into the question and acceptance tests are not often made or published. The manufacturer doubtless runs tests to determine the ratings, etc., but these are seldom made public except in such limited form as to be almost valueless. Hence the following description and results of a series of tests run on a 4-inch single-stage turbine pump may be of interest.

The test was run primarily to determine the pump characteristics and the effect of the stationary exit guide-ring on these characteristics, and as an outcome a short investigation was made of the effect of speed on the characteristics.

Description of Pump.—The pump was of the horizontal, belt-driven, single-stage type, with single 4-inch suction and 4-inch discharge, designed to operate at 1,400 r.p.m., giving 0.7 c.f.s. at 45 feet head. The general design of the pump may be seen in Fig. 1. The single 10-inch runner was of bronze, with eight vanes, all faces being finely finished and polished. The outside stationary guide-ring, also of bronze, is 14 inches, outside diameter, with seven finely polished guides. (See Fig. 2.) There is provided another stationary ring without guides, by the use of which the pump may be operated purely as a centrifugal pump. The balancing of end thrust is by the Jaeger system, with a water-

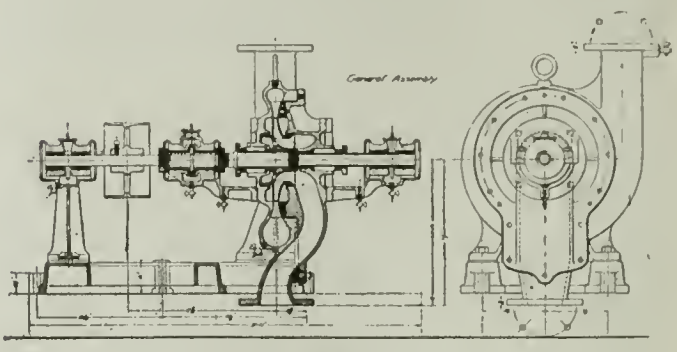


Fig. 1.

cooled thrust bearing as a precautionary measure. The suction entrance is of rather peculiar form to facilitate removal of exit guide-ring and interior examination.

Layout of Test Apparatus.—The layout of the pump, motor, piping and various gauges for the test are shown in Fig. 3.

The pump was set up on a steel tank containing a 2-foot contracted weir. The supply was drawn from the tank on one side of the weir through a common 4-inch strainer foot valve and discharged through 4-inch W.I. pipe, a Venturi meter and gate valve into the tank on the other side of the weir, thence through a pair of wooden baffles (to remove turbulence) and over the weir.

Suction pressures were indicated by mercury suction gauge connected through a catch-cup to the suction pipe below the pump flange. The catch-cup, constructed of ordinary pipe fittings, was provided because of the danger arising when mercury is drawn into a pump. With a cup such as this between the manometer and pump the mercury is prevented from entering the pump. A similar cup was provided on the throat line of the Venturi meter. Speeds were taken by calibrated tachometer.

Method of Test.—A series of tests were run on the pump for speeds from 1,000 r.p.m. up to 1,500 r.p.m., varying by increments of 100, and at each speed the discharge was varied from the maximum (valve wide open) down to the lowest at which steady operation would occur, taking the necessary readings at these two, and about eight intermediate discharges. A further test was run at normal speed (1,400), with the stationary guide-ring removed to determine the effect of the guide-ring on the pump operation.

The results are as shown in the accompanying tables and curves.

In calculating the total operating head of the pump from the readings of the pressure and suction gauges, these readings were corrected to equivalent readings at the centre of the pump and added. The velocity heads being equal may be neglected.

Table No 1 — Test of 4in Single Stage Turbine Pump — Test Data — Speeds of 1000, 1100 and 1200 RPM

No	Pressure Gauge	Pressure Head	Suction Gauge	Suction Head	Total Head	Venturi Gauge	Venturi Disch	Weir Head	Weir Disch	Mean Disch	Pump Speed	— Power — Input	Friction	Water	Output	— Efficiency — Mech	Hyd'c	Hat	No
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.01	3.95	10.05	11.27	15.24	1.680	0.719	2.65	0.718	0.719	995	1420	351	1069	683	75.2	64.0	48.1	1
2	10.00	11.94	8.00	9.03	20.97	1.212	0.610	2.40	0.610	0.610	995	1372	351	1021	798	74.4	78.1	58.1	2
3	14.85	16.79	6.40	7.28	24.07	0.870	0.517	2.14	0.513	0.515	995	1317	351	966	774	73.3	80.1	58.8	3
4	19.40	21.34	5.00	5.75	27.09	0.535	0.443	1.85	0.410	0.411	1000	1248	352	896	694	71.8	77.6	55.6	4
5	21.90	23.84	4.00	4.66	28.50	0.340	0.323	1.58	0.329	0.326	1000	1057	352	705	579	66.7	82.1	54.8	5
6	22.25	24.19	3.40	4.02	28.21	0.252	0.252	1.32	0.255	0.253	1004	970	354	616	445	63.5	72.2	45.9	6
7	21.75	23.69	3.00	3.58	27.27	0.198	0.198	1.11	0.195	0.196	1004	904	354	550	354	60.8	60.7	36.9	7
8	20.22	22.16	2.60	3.14	25.30	0.156	0.131	0.81	0.120	0.125	1005	792	353	437	198	55.1	45.3	25.0	8
9																			9
10																			10
1100 R.P.M.																			
11	3.20	5.14	11.80	13.10	18.24	1.980	0.780	2.79	0.780	0.780	1093	1743	376	1367	887	78.4	64.9	50.9	11
12	13.80	15.74	8.90	10.00	25.74	1.500	0.679	2.55	0.678	0.679	1105	1705	379	1326	1088	77.1	82.1	63.8	12
13	17.96	19.90	7.20	8.06	27.96	1.134	0.590	2.35	0.591	0.591	1090	1656	375	1281	1030	77.5	80.4	62.2	13
14	21.92	23.86	6.20	6.99	30.85	0.846	0.510	2.10	0.498	0.504	1090	1575	375	1200	969	76.2	80.7	61.5	14
15	25.60	27.54	5.10	5.79	33.33	0.550	0.442	1.84	0.408	0.410	1100	1458	378	1080	861	74.1	78.8	58.4	15
16	27.80	29.74	4.10	4.70	34.40	0.360	0.333	1.60	0.333	0.333	1100	1330	378	952	714	71.6	75.0	53.7	16
17	28.10	30.04	3.40	3.94	33.98	0.238	0.270	1.34	0.260	0.265	1100	1175	378	797	561	67.9	70.4	47.8	17
18	27.50	29.44	3.00	3.51	32.95	0.116	0.189	1.09	0.191	0.190	1105	1050	379	671	396	63.9	58.9	37.7	18
19	26.32	28.26	2.60	3.06	31.32	0.056	0.131	0.83	0.127	0.129	1109	925	380	545	252	58.9	46.2	27.2	19
20	13.00	14.94	2.60	3.06	18.00	0.040	0.111	0.72	0.103	0.107	1110	922	381	541	120	58.7	22.1	13.0	20
1200 R.P.M.																			
21	5.00	6.94	12.80	14.20	21.14	—	—	2.90	0.826	0.826	1190	2117	400	1717	1089	81.1	63.5	51.4	21
22	16.00	17.94	10.40	11.57	29.51	1.768	0.735	2.69	0.735	0.735	1200	2082	403	1679	1351	80.6	80.3	64.9	22
23	21.50	23.44	8.10	9.05	32.49	1.450	0.620	2.41	0.616	0.618	1186	1987	399	1588	1252	80.0	78.8	63.0	23
24	27.20	29.14	6.20	7.04	36.18	0.850	0.511	2.13	0.510	0.511	1187	1867	399	1468	1132	78.6	77.5	61.7	24
25	31.00	32.94	4.90	5.61	38.55	0.570	0.418	1.86	0.413	0.416	1190	1735	400	1335	1000	77.0	74.9	57.6	25
26	33.60	35.54	3.90	4.48	40.02	0.375	0.339	1.61	0.337	0.338	1195	1605	401	1204	844	75.1	70.1	52.6	26
27	33.30	35.24	3.40	3.94	39.18	0.211	0.261	1.36	0.264	0.262	1195	1433	401	1032	641	72.1	62.1	44.8	27
28	31.80	33.74	2.80	3.29	37.03	0.114	0.187	1.10	0.193	0.190	1200	1282	403	879	439	68.5	49.9	34.2	28
29	30.40	32.34	2.60	3.06	35.40	0.038	0.108	0.86	0.132	0.120	1195	1109	401	708	265	63.9	37.4	23.9	29
30	13.50	15.44	2.60	3.06	18.50	0.026	0.089	0.55	0.072	0.072	1195	1072	401	671	81	62.6	12.1	7.5	30

Table No. 1.

Table No 2 — Test of 4in Single Stage Turbine Pump — Test Data — Speeds of 1300, 1400 and 1500 R.P.M.

No	Pressure Gauge	Pressure Head	Suction Gauge	Suction Head	Total Head	Venturi Gauge	Venturi Disch	Weir Head	Weir Disch	Mean Disch	Pump Speed	—Power— Input	Friction	Water	Output	Efficiency— Mech	Hyd	Net	No
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
31	8.00	9.94	13.60	15.13	25.07	—	—	2.98	0.859	0.859	1295	2560	430	2130	1391	83.2	62.5	52.0	31
32	20.60	22.54	11.00	12.30	34.84	18.60	0.756	2.74	0.756	0.756	1300	2532	433	2099	1442	82.8	78.3	64.6	32
33	17.20	29.14	8.70	9.79	38.93	13.80	0.651	2.49	0.651	0.651	1300	2483	433	2050	1580	82.5	77.1	65.6	33
34	33.40	35.34	6.90	7.75	43.09	9.70	0.546	2.22	0.541	0.544	1300	2360	433	1927	1442	81.6	75.9	61.9	34
35	38.90	40.84	5.00	5.79	46.63	6.20	0.437	1.92	0.495	0.436	1300	2178	433	1745	1269	80.1	72.7	58.2	35
36	40.40	42.34	4.00	4.70	47.04	4.10	0.355	1.67	0.555	0.395	1300	2075	433	1642	1041	79.2	63.4	50.2	36
37	39.50	41.44	3.30	3.90	45.34	2.45	0.273	1.45	0.280	0.280	1300	1802	433	1369	780	75.9	57.0	43.2	37
38	38.00	39.94	2.80	3.36	43.30	1.19	0.191	1.11	0.195	0.195	1300	1553	433	1120	520	72.1	46.4	33.5	38
39	36.10	38.14	2.60	3.06	41.20	0.37	0.106	0.87	0.134	0.134	1300	1368	433	950	308	68.2	32.5	22.6	39
40	19.00	20.94	2.60	3.06	24.00	0.39	0.101	0.67	0.094	0.094	1295	1340	430	910	145	67.9	15.9	10.8	40
1400 R.P.M.																			
41	11.70	13.64	14.30	15.82	29.46	—	—	3.05	0.892	0.892	1400	3065	471	2594	1639	84.7	63.2	53.5	41
42	24.20	26.14	12.00	13.30	39.44	21.10	0.805	2.85	0.805	0.805	1410	3075	476	2599	1980	84.5	76.2	64.3	42
43	31.70	34.64	9.50	10.59	45.23	16.10	0.704	2.60	0.698	0.701	1410	3028	476	2552	1978	84.5	77.5	65.3	43
44	40.00	41.94	7.80	8.61	50.55	11.40	0.592	2.35	0.591	0.592	1410	2883	476	2407	1866	83.5	77.5	64.7	44
45	45.00	46.94	6.20	6.98	53.92	8.00	0.496	2.10	0.498	0.497	1410	2733	476	2259	1670	82.5	74.0	61.0	45
46	48.20	50.14	4.90	5.56	55.70	5.65	0.417	1.85	0.410	0.414	1410	2580	476	2104	1438	81.6	68.3	55.8	46
47	48.80	49.94	3.90	4.48	54.42	3.65	0.335	1.61	0.336	0.336	1410	2293	476	1819	1139	79.2	62.6	49.6	47
48	46.00	47.94	3.30	3.82	51.76	2.16	0.258	1.35	0.261	0.260	1400	1970	471	1499	839	76.1	56.0	42.6	48
49	45.00	46.94	2.90	3.37	50.31	1.34	0.203	1.10	0.190	0.196	1400	1797	471	1326	596	73.8	44.9	33.2	49
50	42.00	43.94	2.60	3.06	47.00	0.68	0.140	0.85	0.132	0.136	1400	1593	471	1112	398	70.2	35.8	25.1	50
1500 R.P.M.																			
51	14.50	16.44	15.50	17.15	33.59	—	—	3.25	0.923	0.923	1500	3720	523	3197	1932	86.0	60.5	51.9	51
52	31.00	32.94	12.10	13.26	46.10	21.10	0.805	2.85	0.805	0.805	1500	3735	523	3212	2315	86.0	72.1	62.0	52
53	42.50	44.44	9.70	10.81	55.25	15.60	0.693	2.60	0.698	0.696	1500	3550	523	3027	2408	85.3	79.2	67.6	53
54	47.80	49.74	7.60	8.50	58.24	11.50	0.594	2.35	0.591	0.593	1500	3315	523	2792	2158	84.4	77.1	65.0	54
55	52.60	54.37	6.10	6.88	61.25	8.00	0.496	2.10	0.498	0.497	1500	3185	523	2662	1890	83.6	71.2	59.6	55
56	56.50	58.27	5.10	5.79	64.06	5.80	0.412	1.87	0.416	0.419	1500	2835	523	2312	1673	81.5	72.4	59.0	56
57	54.80	56.57	4.00	4.59	61.16	3.50	0.328	1.60	0.334	0.331	1490	2550	517	2033	1262	79.7	62.1	49.5	57
58	52.60	54.37	3.30	3.82	58.19	2.16	0.258	1.35	0.261	0.260	1490	2285	517	1768	944	77.3	53.4	41.3	58
59	51.00	52.77	2.90	3.37	56.14	1.20	0.192	1.10	0.190	0.191	1500	2140	523	1617	669	75.6	41.3	31.3	59
60	45.80	47.74	2.60	3.06	50.80	0.64	0.140	0.85	0.132	0.136	1500	1955	523	1432	430	73.3	30.0	22.0	60

Table No. 2.

The discharge, as already stated, was determined by two methods, namely, Venturi meter and weir. The Venturi meter formula $Q = A\,Cd\,\sqrt{2g\,(H_1 - H_2)}$ in the case of this meter (2-inch throat and $Cd = 0.98$) reduces to $Q = .1754\,\sqrt{H}$ where H is pressure difference in inches of mercury. The Hamilton Smith weir formula $Q = \frac{2}{3}\,Cd.b.\,2g\,H^{3}/_{2}$ was used for the contracted weir and reduced to $Q = 10.69\,Cd\,H^{3}/_{2}$ for this weir. A head discharge curve was plotted to facilitate the work (see curve sheet 1). It was found that for heads on the weir greater than two inches the velocity of approach affected the discharge and a correction was necessary, as shown.

Fig. 2.

The total or net efficiency of the pump is the ratio of the output power to the power delivered to the belt. This efficiency includes the efficiency of the belt drive. It seems proper to include this latter because the pump is belt-driven, the type of drive is a part of the pump itself and the losses introduced by it must always be reckoned on. The mechanical efficiency of the pump is the ratio of the power delivered to the water, to the power input. The ratio of the net power output to the power delivered to the water is the hydraulic efficiency. The product of mechanical and hydraulic efficiencies is the total efficiency.

Results.—Tables No. 1 and No. 2 show in detail the results of the pump test.

Table No. 3 gives the principal results corrected to constant speeds.

The values of Table 3 were calculated from those of Tables 1 and 2 by making use of the following well-known fundamental relations relating to water turbines and centrifugal pumps, namely:—

1. The head varies as the square of the speed, hence $H = H_1 \left(\frac{N}{N_1}\right)^2$

2. The discharge varies as the square root of the head, hence $Q = Q_1 \sqrt{\frac{H}{H_1}}$

3. The power varies as the cube of the square root of the head, hence $P = P_1 \left(\frac{H}{H_1}\right)^{3}/_{2}$

In the above N_1, H_1, Q_1 and P_1 are the actual test results and N, H, Q and P the corrected values.

The results were thus all reduced to a common speed and then plotted on curve sheets.

Discussion of Results.—At normal speed it was found that the pump came very close to the designed require-

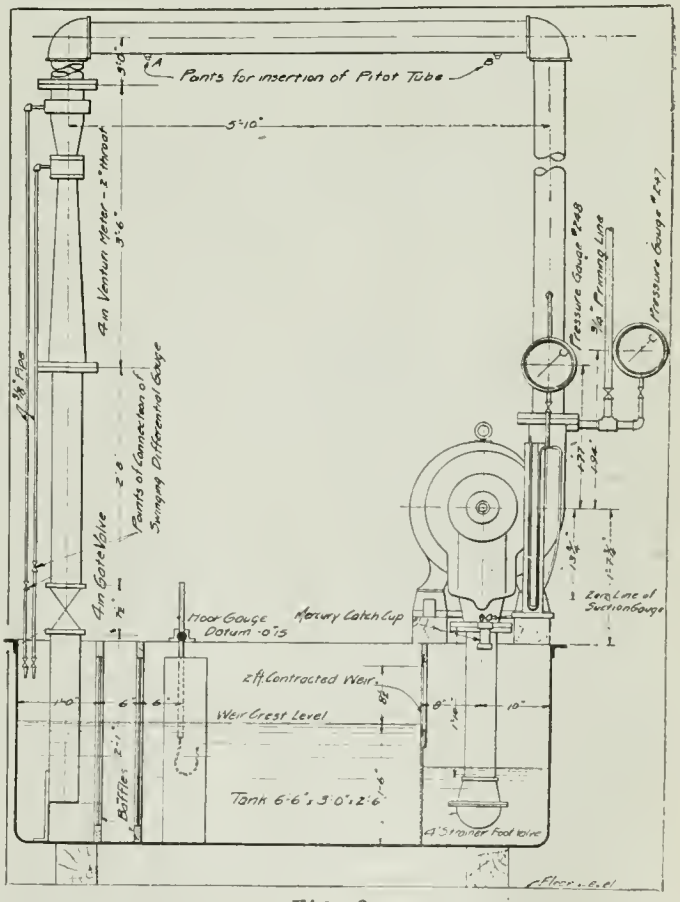

Points for insertion of Pitot Tube
4in Venturi Meter - 2" throat
Pressure Gauge #248
Pressure Gauge #247
Points of Connection of Swinging Differential Gauge
4in Gate Valve
Floor Gauge Datum -0.75
Mercury Catch Cup
2ft Contracted Weir
Weir Crest Level
Baffles
Tank 6'6" x 3'0" x 2'6"
4" Strainer Foot Valve
Long Line of Suction Gauge

Fig. 3.

ments, namely, 0.7 c.f.s. at 45-ft. head and 1,400 r.p.m. For discharges less than the last point plotted on curve sheet it was found that any further closing of the valve caused the discharge to drop rapidly, finally ceasing

altogether although the valve was still apparently partly open. This may have been due to the type of valve employed which was simply a standard 4-inch gate valve with a certain amount of play in the disk which would render the necessary fine adjustments impossible. It may also have been due to the fact that the head in the upright discharge pipe to the elbow was greater than the head corresponding to this small discharge and the pump discharge thus simply fell off, no water passing along the horizontal portion of the discharge pipe. The conditions changed so rapidly at the small discharges that no results could be obtained.

The curve of efficiency is of good form, giving, as was to be expected, maximum efficiency at normal discharge and being comparatively flat at this point so that for slight increase or decrease of discharge the change in efficiency is slight.

The efficiencies obtained are quite high for a pump of this size acting under so low a head, being slightly over 65 per cent. Although customary in large multi-stage pumps to obtain efficiencies in the neighborhood of 80 per cent., efficiencies of 60 per cent. or over may be considered very good in pumps of this size. In small single-stage pumps the bearing and gland friction is relatively much larger than in larger multi-stage pumps, and uses a much larger part, comparatively, of the input power, reducing the mechanical, and, therefore, the net efficiency. Thus, if the shaft of a large pump is twice the diameter of that of a small pump, while the power is eight times as great, the friction loss is only increased to double that of the small pump. The power consumed in overcoming friction (running pump light) is in the pump, as in other machines, a certain fraction of the total input, and this fraction decreases as the pump increases in size, so that evidently higher mechanical efficiencies should be expected in pumps of large size than in small size ones. Such efficiencies as have been obtained from this pump are the result of very careful design and accurate workmanship, which in turbine pump work are absolute necessities when high efficiencies are sought. In addition, as previously mentioned, the impeller and guide-ring, guides, passages and surfaces were all finely finished and polished in this pump, the construction being so modified as to permit of this being done.

Test of 4-in Single Stage Turbine Pump
— Test Data Corrected to Constant Speeds —

Table No 3

No	Test Speed	Speed N	Head H	Disch Q	Power P	Effy E
1	2	3	4	5	6	7
1	995	1000	15 40	0 712	1435	481
2	995		21 10	0 613	1338	581
3	995		24 30	0 517	1330	588
4	1000		27 09	0 411	1243	556
5	1000		28 50	0 326	1057	548
6	1004		28 00	0 252	958	459
7	1004		27 00	0 195	890	369
8	1005		25 05	0 124	780	230
9						
10						
			1100 RPM			
11	1093	1100	18 45	0 785	1775	309
12	1105		25 50	0 676	1682	638
13	1090		28 43	0 596	1700	622
14	1090		31 40	0 503	1617	615
15	1100		33 33	0 410	1458	584
16	1100		34 40	0 333	1330	537
17	1100		33 98	0 265	1173	478
18	1105		32 60	0 189	1034	377
19	1109		30 80	0 128	903	272
20	1110		17 70	0 106	899	130
			1200 RPM			
21	1190	1200	21 50	0 833	2168	514
22	1200		29 51	0 733	2082	649
23	1186		33 20	0 625	2053	630
24	1187		37 10	0 517	1938	617
25	1190		39 10	0 419	1772	576
26	1195		40 30	0 339	1622	526
27	1195		39 50	0 263	1449	448
28	1200		37 03	0 190	1282	342
29	1195		35 65	0 120	1120	239
30	1195		18 65	0 072	1085	75

No	Test Speed	Speed N	Head H	Disch Q	Power P	Effy E
1	2	3	4	5	6	7
31	1295	1300	25 30	0 862	2585	520
32	1300		34 84	0 756	2532	648
33	1300		38 93	0 651	2489	696
34	1300		43 09	0 544	2360	619
35	1300		46 43	0 436	2178	582
36	1300		47 04	0 355	2073	502
37	1300		45 34	0 276	1801	452
38	1300		43 30	0 193	1553	333
39	1300		41 20	0 120	1363	226
40	1295		24 15	0 097	1333	108
			1400 RPM			
41	1400	1400	29 46	0 892	3065	535
42	1410		38 80	0 799	3005	643
43	1410		44 50	0 696	2965	653
44	1410		49 80	0 588	2820	647
45	1410		53 10	0 494	2675	610
46	1410		55 00	0 411	2545	558
47	1410		53 70	0 334	2245	496
48	1400		51 76	0 260	1970	426
49	1400		50 31	0 196	1797	356
50	1408		46 97	0 136	1583	254
			1500 RPM			
51	1500	1500	33 59	0 923	3720	519
52	1500		46 10	0 805	3733	620
53	1500		56 07	0 696	3550	686
54	1500		58 24	0 593	3315	650
55	1500		61 15	0 497	3185	596
56	1500		64 06	0 419	2835	590
57	1490		62 10	0 333	2605	495
58	1490		39 00	0 262	2333	413
59	1500		56 14	0 191	2140	313
60	1500		50 77	0 136	1955	220

Table No. 3.

HYDRO-ELECTRIC PLANT OF UNUSUAL DESIGN.

THERE is nearing completion at Wissota, Wisconsin, a new plant, two features of construction of which are unique and therefore of particular interest to engineers, especially those interested in hydraulics. These two features are the ten sluice tubes which discharge into the draft tubes and the design of the spillway gates.

The ten sluice tubes are carried directly through the dam, sloping slightly downward and discharging horizontally into the draft tubes. The four middle draft tubes consist of two sluice tubes each, whereas the two end draft tubes have only one tube each. The flow of water through the sluice tubes is controlled by means of gate valves, eight being motor-operated and the other two being hand-operated. These sluice tubes are five feet in diameter with a total capacity of 10,000 second-feet, increasing the capacity of the spillway, obviously, by that amount. This gain in spillway capacity, however, is chiefly an incidental result, the primary object of the tubes being to produce an "injector effect" in the draft tube and thereby to tend to increase the partial vacuum on the discharge side of the turbine. From tests which have been made on a smaller scale it is estimated that the efficiency of the turbine will be increased approximately four per cent. by this arrangement. At present, efforts are being made to secure a patent on this particular type of tube. It is understood, of course, that the sluice tube will be used only when the river is supplying water in excess of that being used by the plant.

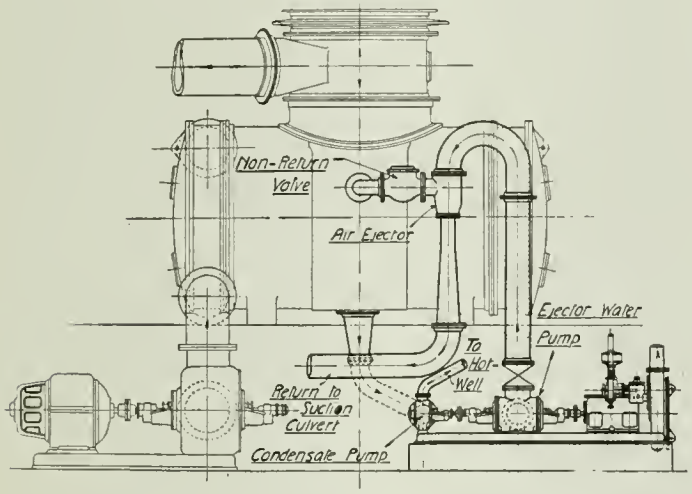
The spillway gates, thirteen in number, each sixty-four feet wide, are of the type known as the Stauwerke automatic gate. As mentioned, this design of gate has never before been used in America, but is said to be giving remarkably good service in Switzerland under conditions very similar to those prevailing at Wissota. The gate is mounted on a horizontal axis at right angles to the stream, and is so adjusted that a counterweight just balances the pressure of the water at normal level. Any slight rise of level thereby increases this pressure and tilts the gate, thus permitting a much greater quantity of water to pass through the spillway. These gates are expected to regulate the water level of the pond to within four inches of normal under all ordinary conditions, and never to allow it to rise more than six inches above normal even under the most extreme conditions. In addition to being automatic and providing close regulation, the Stauwerke gate possesses a third advantage in that it is curved downstream and hence presents a concave surface to the stream. This design prevents all clogging by drift or ice.

With these two distinctive ideas in dam construction being thus tried on a large scale, the results which the Wisconsin-Minnesota Company obtains at Wissota will no doubt be well worth the attention of all engineers interested in hydraulic power development.

TESTS ON SURFACE CONDENSING PLANT.

FOLLOWING are the results of tests carried out on one of five similar surface condensing plants with Willans rotary air pump system, installed at the Durnsford Road power house of the London & South Western Railway Co., England:—

	Test No. 1.	Test No. 2.	Guarantees.
Load, lbs. of steam per hour	68,176	68,389	68,000
Vacuum at steam inlet to condenser, corrected to 30" barometer	28.73"	28.76"	28.5"
Corresponding steam temp.	86.6° F.	86° F.	92° F.
Condensate temperature	82° F.	82.5° F.	87° F.
Difference between condensate and vacuum temperatures.	4.6° F.	3.5° F.	5° F.
Circulating water inlet temp.	58.5° F.	58.5° F.	65° F.
" " outlet "	80.8° F.	81.1° F.	83° F.
Difference between circulating water outlet and vacuum temperatures	5.8° F.	4.9° F.	9° F.
Cooling water, gals. per hour	318,000	317,600	396,600
Duration of test	60 min.	60 min.	



The tests were carried out after the plant had been in service for a considerable period, and in the presence of the representatives of the consulting engineers, Kennedy & Donkin, and of Herbert Jones, chief electrical engineer of the railway.

As mentioned above, the station contains five identical plants in addition to two smaller similar plants. Each of the plants embodies the rotary air pump system devised by Willans & Robinson, Limited, of Rugby, England. The main feature of this system is that the circulating water is passed through an ejector, which is shown in the accompanying drawing, and which takes the place of the ordinary air pump. A separate condensate pump is provided to withdraw the condensed steam from the surface condenser and to return this to the hot well. An automatic non-return valve is placed between the air ejector and the main condenser body, so as to prevent water being drawn into the condenser in case of failure of the ejector.

There are three common forms of application of the system known as the "series," the "shunt" and the "separate pump" types. In the case of the "series" type of plant, the whole body of the circulating water is passed through the air ejector before entering the condenser. That is, the circulating pump is designed for the normal quantity of water required by the condenser, but allowance is made in calculating the head for the necessary drop across the air ejector.

In the case of the "shunt" system, the cooling water for the condenser and the ejector water are delivered in parallel, and the ejector water is returned to the source of supply or to the circulating water suction. In other words, the circulating pump is designed for the normal head required by the lay-out of the plant with allowance for condenser friction and the quantity delivered is that needed for the condenser itself, plus the necessary water for the air ejector.

The "separate pump" type, of which the L. & S. W. installation is an example, differs from the "shunt" system only in that a separate pump is provided for delivering the air ejector as apart from the main circulating water pump which supplies the condenser in the ordinary way.

In the L. & S. W. installation, both the main circulating pump and the ejector pump draw their water by means of a common suction pipe from the main suction culvert, which runs the full length of the engine room. The water coming from the condenser itself is, of course, heated and passed to the delivery culvert, but the air ejector water is returned to the suction or inlet culvert.

It will be noted that in this instance the circulating pump is driven by means of a continuous current motor, whereas the ejector pump and condensate extraction pump are driven by a small steam turbine.

The tests show that the vacuum attained is substantially above that guaranteed, and that there is very slight difference between the circulating water outlet and vacuum temperatures.

PIPES OF ELECTROLYTIC IRON.

A firm at Grenoble, in France, is now manufacturing pipes of electrolytic iron up to five metres (16.4 ft.) in length, 300 mm. (nearly 12 in.) diameter and 3 mm. (⅛ in. bare) thick. The metal as taken from the bath is hard and very brittle, but after a special and careful heat treatment becomes of excellent quality and has a tensile strength of over 25 tons per square inch in any direction. They are stated to be superior to cast-iron pipes in several respects.

AMERICAN LOCOMOTIVE BUILDING.

The demand for locomotives in the United States continues active. The Southern Railroad Co. contemplates buying 45 engines, the Chicago, Burlington and Quincy 30, the Union Pacific 15 and the Duluth, Mesaba and Northern 6. The American Locomotive Co. will build 40 consolidation engines for the Italian State Railways, 10 Pacifics for the El Paso and South-Western Railroad, and 5 each for the Delaware, Lackawanna and Western, the Central Railroad of New Jersey and the Western Pacific. The Louisville and Nashville is building 8 Mikados in its own shops, and will soon begin 8 more.

The Southern Canada Power Co., Limited, have removed from 42 St. Francois Xavier St., to 330 Coristine Building, Montreal.

The mining industry in Spain has acquired more importance than is generally known. The output of iron ore in 1915 was 5,617,839 tons. Pyrites were raised to the extent of 730,568 tons; iron ore briquettes to the extent of 555,357 tons and manganese ore to the extent of 14,328 tons.

The promoters of the Oriental Iron Smelting Co., of Japan, propose to work the Taochun iron mine at Anhui, China, by taking over a concession obtained by the Chino-Japanese Industrial Development Co., from the Peking Government. The company proposes to start with a capital of $12,462,500.

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BOOK REVIEWS.

Hydro-Electric Power—Vol. II. Electrical Equipment and Transmission. By Lamar Lyndon. Published by the McGraw-Hill Book Co., New York. First edition, 1916. 360 pages, 194 illustrations, 28 tables, 6 x 9 ins., cloth. Price, $3.50. (Reviewed by H. D. Johnston, contract manager, Eugene F. Phillips Electrical Works, Limited, Montreal.)

The book is divided into thirteen chapters, the first five of which deal with power house equipment, seven with transmission lines, and the last with sub-stations. Considering the scope of the book, the subjects are very thoroughly dealt with, particularly the sections dealing with transmission lines.

Chapter 1 contains a short description of generators and exciters. This subject, however, is dealt with only in a general manner, and a more detailed description of some of the modern large generators mentioned would be interesting.

Chapter 2 describes in a practical manner the various types of transformers. The different methods of connection are clearly discussed and the theory explained with the aid of simple formulæ and vector diagrams.

The chapter on switch-boards contains descriptions of various types of modern switch-boards, considerable attention being given to exciter boards in connection with which is shown a diagrammatic method of computing bus-bar currents. Clear descriptions are given of all the usual instruments and accessories used in the modern power house, including the Tirrell regulator and the multi recorder. The chapter closes with specifications for high-tension switching apparatus

In the chapter on power house cranes some of the reference letters for clearances are omitted on the diagram, and figures referred to in the text at the end of the chapter are wrongly numbered.

An outline is given of power house design, but, as the author points out, no definite rules can be laid down owing to the widely differing conditions of each undertaking. In the same chapter, tests on hydraulic turbines and generators are described.

Wires and cables for transmission lines are discussed in Chapter 6 with a comparison between aluminum and copper lines, the author indicating a preference for the former.

One chapter is devoted to insulators for high-voltage lines and a good description is given of modern insulators, advising the points to be considered in their selection and including the American Institute of Electrical Engineers' specifications for testing insulators. Pole and tower lines are fully described in Chapter 8, including detailed descriptions of materials and erection. Some useful formulæ and tables are given, also specifications for material and a comparison of costs between a pole line and steel tower line.

In the chapter on electric circuits the author very clearly explains the theory of A.C. circuits by means of diagrams and concisely written text.

The chapter on calculation of transmission lines is perhaps the best in the book, and is very thoroughly treated. Three sets of formulæ are given, the last being somewhat complex, while the first two are comparatively simple and sufficiently accurate for ordinary use. Dwight's chart for transmission line calculations is also given, being bound on the inside cover at the end of the book, and forms a very rapid and fairly accurate method of calculation, necessitating the use of only the simplest formulæ. Tables are given of Corona voltage limits and of reaction and capacity of lines.

Chapter 11 deals with stresses on transmission lines, which are fully described with formulæ for finding same. The leading tables devised by the N.E.L.A. are also included. In the chapter on line protection are described the theory and construction of aluminum and multi gap arresters; a description is given of Professor Creighton's arc suppressor and various types of arcing rings and horns for insulators. In-door and out-door sub-stations are illustrated and described in the last chapter.

The book is well printed, the diagrams being very clear and all formulæ, of which there are some 146, being numbered for reference.

No mention is made of underground cables, and as these are becoming more extensively used in connection with transmission lines for voltages up to 25,000, a short chapter on the subject giving some details of their construction and method of installation might have been included with advantage.

The author has covered very completely the subjects enumerated and the book will be found very valuable not only to the student but also to the engineer.

Mechanical Equipment of Buildings—Vol. I., Heating and Ventilating. By Louis Allen Harding and Arthur Cutts Willard. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1916. 615 pages, illustrated, 6¾ x 9¼ ins., leather. Price, $4.00 net. (Reviewed by Harry H. Angus, B.A.Sc., MacMullen, Riley and Angus, consulting engineers, Toronto.)

This book is the first of a series of books being written by the same authors and dealing with the mechanical equipment of buildings. This first volume deals only with heating and ventilation of buildings and other

items such as power plants, elevators, lighting systems, etc., are to be dealt with in subsequent volumes.

The present book without doubt contains the best and most complete information of any book so far published in connection with heating and ventilation. The authors have drawn upon all available sources of information and have grouped this into such form that it is ready for quick reference. The method of using the different formulas is well explained by means of various examples and it is to be noted that practically all examples are those dealt with in actual practice. In a great many cases all the calculations required in the complete design of a system for a particular building are made and explained. Very little space has been devoted to electrical heating and other questions which at present are of merely theoretical interest and the whole book is arranged to deal with the practical problems which are met with every day. Particular care has been taken in grouping the information and credit has been freely given in the text to the sources from which all information has been obtained. The illustrations in most cases are drawn to scale and are typical working drawings and much superior to the usual type of drawings found in books of this type. They are also very numerous and all points brought out in the text are well illustrated, thus making the book comparatively easy to follow. This book also contains a great deal of original information, particularly that giving tests on different types of boilers and radiators. Up to the present time, the books published dealing with heating and ventilation have been either very elementary or have only dealt with one phase of the question so that practically all published information had to be gathered from papers read before engineering societies and from short articles.

The authors have therefore given to heating engineers a pocket book quite as valuable along this line as Kent's pocket book is to mechanical engineers.

The first and second chapters deal with the properties of steam, water and air which are required in dealing with the science of heating and ventilation. Chapter 3 gives information regarding the heat transmission of various types of building construction and consists of information collected from various sources and placed in a form ready for reference. The next chapter gives information regarding the standard types of radiation at present in use as well as data regarding the heating effect of radiators under different conditions. The next chapters deal with fuels and boilers. The question of fuels is gone into very fully as well as various methods of testing both fuels and flue gases. Under the head of boilers is given a number of tests and comparison of different types but the question of smokeless combustion is not dealt with as fully as might be desired, in view of the present widespread interest in the elimination of smoke nuisance in cities. The chapters dealing with steam and hot water heating are quite complete and in addition to the usual information, describe the different appliances and systems on the market, giving cuts and general dimensions as well as typical arrangements and design of systems. The question of friction in hot water systems is dealt with thoroughly and charts and formulas given and explained. Forced hot water and vacuum steam systems for large plants are dealt with later in the book.

In the latter part of the book is given some excellent reference information regarding pipe sizes, valves, fittings and also valuable data on pipe hangers and supports, a good deal of which has not been published before.

Six chapters are devoted to hot air heating, covering furnace heating, indirect heating, forced blast heating and air washing. This part of the book is well written and contains much valuable information required in dealing with hot air heating, and sufficient information to solve any problems arising in this connection. The question of friction in air ducts is carefully dealt with and formulas and charts are given which are required to design a balanced system.

Numerous plans of buildings are shown in order to deal fully with the problems involved and the design of systems for these buildings is shown together with all calculations required. Suitable designs of fans as well as their proper location and connections to the duct system are described and shown as well as methods for fan testing. The chapter dealing with air conditioning contains the latest data on this important subject, including a table giving the properties of mixtures of air and saturated water vapor as well as a psychrometric chart worked up by one of the authors.

Spon's Electrical Pocket-Book. By Walter H. Molesworth. Published by E. and F. N. Spon, Limited, London; Spon and Chamberlain, New York. 488 pages, 325 illustrations, 6¾ x 4¼ ins., cloth. Price, $1.75 net. (Reviewed by Alfred S. L. Barnes, Hydro-Electric Power Commission of Ontario, Toronto.)

The preface sets forth that this book is written for practical engineers who may seek for general information, tables and formulæ on electrical subjects. It is a handy and useful compilation covering, for its size, a very considerable range of data, mainly electrical, of which a good portion will be of general utility anywhere. So far as this country is concerned, however, there are several sections which would be of little use, *e.g.*, the British Home Office Regulations, the British Board of Trade Regulations, the Rules of the Institution of Electrical Engineers, the sections on tramways and railways and the British standardization rules for electrical machinery. The book is convenient in size and the information is arranged in suitable sequence and there is a copious index at the end consisting of some 20 pages.

Stresses in Structures. By A. H. Heller, C.E., late professor of structural engineering, Ohio State University. Third edition, 1916, revised by his successor, Clyde T. Nanis, Mem.Am.Soc.C.E. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal. 374 pages, 230 diagrams, 6 x 9 ins., cloth. Price, $2.75 net. (Reviewed by A. H. Harkness, Harkness & Oxley, consulting engineers, Toronto.)

The first edition of this work was the publication of the manuscript used by the author for his lectures in the university. This third edition has been revised and the explanations expanded so as to make the work more easily read by the beginner. It follows that the book has been written from the standpoint of a lecturer who wished to produce a text book for his students rather than a reference book for the profession of engineering. As a text book to be read in conjunction with a course of lectures it would be very useful. The student who wished to use the book for self instruction would probably find it too condensed to enable him to follow it readily. He would, moreover, require a good grounding in mathematics to be able to do so at all. The busy engineer who wishes to refresh his memory, or to get information on some of the subjects covered in the book, will be able to do so with a minimum amount of reading.

The book, within its limit of 350 pages, covers practically the whole subject of strength of materials, and status of beams and determinate trusses. The first and second chapters treat of stresses and deformations in materials. The third chapter deals with coplaner forces, the laws of equilibrium and their application, and the fourth and fifth chapters with the methods of determining the stresses in trusses. The sixth, seventh and eighth chapters form a fairly complete treatise on the beams, covering the stresses in beams and girders, the deflection of beams, the bending moments and shears in simple beams, and in restrained and continuous beams. The question of live loads with maximum moments, and shears, for simple and continuous beams is also discussed. The ninth chapter is devoted to columns and the tenth, eleventh and twelfth to roof and bridge trusses with stationary loads. Chapter thirteen covers railroad bridges with moving loads, and fourteen treats of horizontal loads on bridges, lateral bracing and portals. Each of the above subjects is more completely covered than one would expect to find in a book of this size.

The order in which the different subjects are taken up and discussed is not that usually followed in text books, but it is logical. It may, however, require a little harder application on the part of the student to follow the work.

One feature that commends itself is the author's method of analyzing a stress condition in some simple structure or shape, and solving it by ordinary mathematics before going into the higher mathamatical analysis of it. This is well illustrated in his discussion of the moment of resistance of the beam where he shows how to find the moment of resistance of a rectangular beam by elementary mathematics and statics. The result is that the student gets a much clearer conception of the meaning of the more complete mathematical analysis which follows. Too often in text books the discussion of a problem begins and ends with the mathematical analysis.

PUBLICATIONS RECEIVED.

Annual Report, 1916, of the Canada Iron Foundries, Limited, Montreal.

American Waterworks Association.—Proceedings of the 36th year of the American Waterworks Association, Baltimore, Md.

Handbook on Wood Preservation.—Published by the American Wood Preservers' Association, Mount Royal Station, Baltimore, Md.

Public Road Mileage and Revenues in the New England States, 1914.—Bulletin No. 388 of the United States Department of Agriculture, Washington, D.C.

Mineral Production.—A general summary of the mineral production of Canada during the calendar year 1915. Issued by the Department of Mines, Ottawa.

Dominion Water Power Branch.—Annual report, 1914-1915, of the Water Power Branch, Department of the Interior, Ottawa. J. B. Challies, C.E., superintendent.

Subsidence Resulting from Mining.—By L. E. Young and H. H. Stoek, being Bulletin No. 91 of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Operating Details of Gas Producers.—By R. H. Fernald. Bulletin 109 issued by the Bureau of Mines, Department of the Interior, Washington, D.C. Van H. Manning, director.

American Society for Testing Materials.—Proceedings of the 19th annual meeting of the society held at Atlantic City, N.J., June 27-30, 1916. Part 1 contains committee reports and tentative standards, and Part 2 technical papers.

Department of Trade and Commerce.—Canada year book, 1915. Valuable reference volume. Special articles on "Local Government of Canada," "Economic Geology Flora and Fauna of Canada." Section 8 devoted to statistics of railways, canals, telegraphs, telephones, etc. Price, $1.00.

International Marine Diary, 1917.—The object of this useful volume is to supply the commercial world in concise form, data relative to the development of Great Britain's trade with foreign countries. Sterling conversion tables, the shipping, banking, postal, cable, and financial facilities of each country listed are given. Price, five shillings and ninepence. Published by Syren and Shipping, 91 Leadenhall Street, London, E.C.

CATALOGUES RECEIVED.

Wedge Optical Pyrometer.—An 11-page illustrated pamphlet issued by Barnes & Morris, London, Eng.

Holt Roof Vent and Leader Connections.—Illustrated booklet containing 19 pages, issued by The Barrett Company, New York.

American Drilling Machines.—Catalogue No. 145 of The American Well Works, Aurora, Ill., contains 112 pages, and is well illustrated.

London Concrete Block Machine.—A 40-page illustrated booklet issued by The London Concrete Machinery Co., Limited, London, Ont.

Gun-crete for Protection.—Bulletin No. 5 of the Cement-Gun Construction Co., Chicago, Ill., describing, with illustrations, their Gun-crete work on various buildings.

Buda Electric Storage Battery Trucks.—Illustrated folder issued by The Buda Company, Chicago, Ill., through their agents, the Federal Engineering Co., 92 Sherbourne Street, Toronto.

Lubrication.—A 12-page illustrated leaflet published by The Texas Co., New York, containing articles on flash and fire tests, the Universal Unaflow engine, lubrication of sugarhouse machinery, etc.

Sun Oils.—Volumes 1, 2 and 3 of a series of pamphlets issued by the Sun Co., 1428 South Penn Square, Philadelphia, Pa., descriptive of the early days and later developments of the oil business.

Lubrication.—A 16-page illustrated pamphlet published by The Texas Co., 17 Battery Place, New York City, describing steam cylinder lubrication, modern apparatus for the scientific lubrication of machinery, etc.

American Standard Types of Centrifugals.—Catalogue No. 132 of The American Well Works, Aurora, Ill., describing their standard types of American centrifugal pumps. Contains 104 pages and is well illustrated.

Spraco Equipment.—Bulletin No. 250, issued by the Spray Engineering Co., 93 Federal Street, Boston, Mass., which illustrates and describes their "Spraco" equipment for washing and cooling the ventilating air for steam turbine-driven generators.

American Deep Well Pumps.—Illustrated catalogue No. 130, issued by The American Well Works, Aurora, Ill. This catalogue, comprising 63 pages, contains two sections. Section 1 describes American deep well power heads, and Section 2, American deep well steam pumping engines.

Editorial

COMPENSATION OF ENGINEERS.

According to a report made to the American Society of Civil Engineers by a special committee, the average compensation of engineers is $3,985 per annum. The research work of the committee was supposed to have been conducted among non-members as well as members of the society. Engineering Record, of New York, in commenting editorially upon this report, scouts the idea of the average engineer's income being so near the $4,000 mark, and states that the committee should withdraw its report. We entirely agree with our contemporary in this matter and feel certain that the average compensation of civil engineers on this continent—counting in all classes—is considerably less than $3,985.

The average income of the members of the American Society of Civil Engineers may be that amount, but the average salary of engineers who are not members of the society would be so much lower that it would materially reduce the total general average. Data was obtained from 5,042 out of 7,037 members of the society, but only 1,316 non-members reported to the committee.

The committee itself acknowledges that low-salary data is lacking and explains that it was difficult to arrive at the salaries of engineers in state, municipal and railroad employ, etc. Engineering Record points out that a census of the engineers employed in the eastern district of New York State shows 253 men with an average compensation of $1,775. Only eight were up to the committee's average of $3,985. Of these 253 men only 44 were found in the membership list of the society with an average of $2,857, leaving an average of $1,547 for the other 209. This suggests the unreliability of returns which are compiled mainly from members of the society.

No doubt the report of the committee of the American Society is an extremely valuable document and shows the average remuneration of the members of that society, but it evidently cannot be taken as a fair determination of the average compensation of civil engineers in general.

AFTER-THE-WAR PROBLEMS.

During the past few weeks there have been held the annual meetings of some of our important banking and financial institutions. At many of them there have been delivered addresses which have dealt more or less fully with the trade conditions that are likely to obtain after the war. One of the most remarkable of these addresses was that delivered by Sir Herbert Holt at the annual meeting of the Royal Bank of Canada a few days ago. He pointed out that the present prosperity had no permanence about it and that the war was the only thing which had accelerated the wheels of industry; that the termination of the war must react on all industry with very far-reaching results. Factories that were now running full time and overtime and were exclusively engaged in the manufacture of munitions would close. Kindred industries, stimulated by high prices, would suffer by the return of more ordinary conditions. Exports, he anticipated, would decline as Europe imported less and commodity prices would recede. Labor will become a glut in the market, only to be aggravated by the return of soldiers in large numbers.

Leaders of thought in all parts of the Dominion have pleaded and are still pleading for some intelligent action to be taken in order to solve the problems which must confront us as a people after the war is over. The great majority of our people are seized of the importance of action in this direction.

It seems that practically every country in the world is exercising itself in intelligent effort to meet and solve these problems in a businesslike way except Canada. Is it not foolish for us as a people to go blundering along trusting that something will turn up which will enable us to evade the difficulties which other nations feel sure are bound to confront them when hostilities cease.

ENGINEERING SOCIETIES AND THE WAR.

While it will be generally conceded that technical societies were founded for scientific and educational work and that they would be going out of their province if they began meddling with matters of trade and industry, there is, nevertheless, a growing conviction on the part of many members of such societies that the time has come for some of them, at least, to concern themselves with the business side of engineering more than they have done in the past.

There is much to be said on both sides of this question. We have great respect for those who maintain, and maintain stoutly, that it is not the function of a technical society to discuss, for instance, the matter of workmen's compensation, or the limitation of profits. These and kindred subjects are suitable for boards of trade, but not for the technical society. The discussion of business questions should be left to business organizations, but the technical society should confine itself to scientific discussion.

Undoubtedly the view that our scientific societies should lend themselves more generally to the discussion of business matters has been accentuated since the war introduced a new series of economic problems, in the solution of which science will be called upon to play a most important part.

If, as is so often stated, science is to be the ruling factor in the race for national supremacy after the war, would it not seem to be the wiser course for societies which were created for the consideration of scientific questions to stand by their guns and not permit their energies along that line to be scattered by the introduction of discussions of a totally different character?

ANNUAL CONFERENCE OF COUNTY ROAD SUPERINTENDENTS AND ENGINEERS.

We have been sent a programme of the third annual conference on road construction for county road superintendents and engineers. This year the conference is to be held March 27th to 30th,

These yearly conferences which are held under the auspices of the Ontario Department of Public Highways

cannot but be effective and beneficial in a number of ways, not only to those who are privileged to attend but to highway engineering generally. They foster a spirit of co-operation between the engineers of the Provincial Department of Highways and the men out in the field who are carrying out the actual work, which is most desirable. At these annual conferences the questions growing out of the design, construction and maintenance of county roads are freely discussed. They constitute a clearing house for ideas and the experience gained at them cannot help but lead to a broader and better understanding of road work.

PERSONAL.

JOHN FAIR has been elected chairman of the water commission, Brantford, Ont.

J. ARCHIBALD KERR has been elected chairman of the Water Commission, Petrolia, Ont.

Dr. J. A. AMYOT, director of the Ontario public board of health laboratories, Toronto, has been appointed sanitary adviser in England to the Canadian forces.

S. W. BARNSTEAD, C.E., has been appointed engineer for the Holden end of the big drainage scheme in the district of Holden and Daysland municipalities, Alberta.

Lieut. J. V. DILLABOUGH, A.M.Can.Soc.C.E., for the past four years assistant chief engineer of the Hudson's Bay Railway, has been appointed second in command of the 228th Battalion, Winnipeg.

E. EVANS, formerly inspector of the sewer maintenance department, Edmonton, Alta., has been appointed superintendent of the sewage disposal plant with control of all matters pertaining to the sewers of the city.

F. J. GLOVER, municipal engineer, Langley, B.C., has enlisted for overseas service, and will leave for England in about six weeks' time, in charge of a tunnelling company with the Engineers of North Vancouver.

Capt. A. GERALD KNIGHT, a graduate of the Department of Applied Science and Engineering of the University of Toronto, who recently was reported to have been awarded the D.S.O., and later the M.C., is now reported missing.

F. P. BRADY, general superintendent of the Canadian Government Railways, who has been a patient in a Rochester, Minn., hospital for the past four months, is so far recovered as to be able to return to Winnipeg, but not yet able to return to duty.

Lieut.-Col. F. O. W. LOOMIS has been awarded the D.S.O. He was, prior to the war, a member of the Montreal contracting firm of D. C. Loomis & Sons. He went to the front with the first Canadian contingent, and is now with the headquarters staff in England.

J. G. MAYO, formerly assistant general manager of the Mattagami Pulp and Paper Company, has joined the sales staff of the Canadian Fairbanks-Morse Co., Limited, with headquarters at Montreal, as head of that firm's newly organized pulp and paper mill department.

A. E. GRIFFIN, of the firm of Foley, Welch & Stewart, Vancouver, B.C., has been asked to report at once in England. He is to be given charge of a corps of railway construction men. The appointment has been made by Col. J. W. Stewart, deputy director of light railway construction in France.

M. A. GRAINGER, for the past two years acting chief forester for the forest branch of the Department of Lands, British Columbia, has been appointed to the office of chief forester in succession to Mr. H. B. MacMILLAN, who recently resigned to accept the position of assistant manager of the Victoria Lumber and Manufacturing Company, with headquarters at Chemainus, B.C.

Capt. H. A. WOOD, son of Mr. D. O. Wood, general freight agent of the Allan Line, Toronto, has recently received his promotion to flight commander, with rank of captain. Capt. Wood is a graduate of the School of Practical Science, Toronto, 22 years old, and was with the engineering staff of the Toronto Harbor Commission prior to going overseas.

Second-Lieut. YVES LAMONTAGNE, of the Royal Engineers, was wounded on the 12th of January. Lieut. Lamontagne had just been graduated in Applied Science at McGill University when he enlisted as a private in a railway construction corps in July, 1915. He went to the front with that unit and in January of last year was transferred to the Royal Engineers, and given his commission as second-lieutenant. He is at present serving with the 74th Field Company. His home is in Montreal.

JESSE K. GIESEY has been admitted to partnership in the firm of Geo. W. Fuller, consulting engineers, New York City, and the firm name has been changed to FULLER & McCLINTOCK. Mr. Jas. R. McClintock has been associated with Mr. Fuller for a number of years. Mr. Giesey graduated at Rensselaer Polytechnic Institute in 1904. He was a member of the staff of Hering & Fuller, 1904-11; assistant engineer with Hering & Gregory, 1911-14; and latterly in charge of the outfall sewer, pumping station and sewage treatment works at York, Pa.

Major E. G. M. CAPE, president of the E. G. M. Cape & Co., Limited, contractors, Montreal, was mentioned in the recent despatches by Field Marshal Sir Douglas Haig. Major Cape commands the 106th Battery Canadian Heavy Siege Artillery, one of the finest batteries that ever left Canada. Major Cape, who is a B.Sc., was at one period lecturer on mechanical engineering at McGill University, and has also held positions with public companies. He is a member of the Canadian Society of Civil Engineers.

OBITUARY.

Lieut. RONALD HAYWARD, son of Mr. R. F. Hayward, general manager of the Western Canada Power Company, Vancouver, B.C., who joined the Royal Horse Artillery in England, was recently killed in action at Salonika.

R. E. SPEAKMAN, city engineer of Brandon, Man., for the past nine years, passed away in a Rochester, Minn., hospital on January 13th at the age of 70 years. Mr. Speakman was also city engineer of St. Catharines before going to Brandon, and at one time had an office in Toronto. He was a member of the Canadian Society of Civil Engineers.

CORRECTION.

In last week's issue in the article "Analysis of Chicago By-law for Flat Slabs," by W. W. Pearse, Equation 19 should have read: $Mt = wL^3/28.5$. Equation 20 should have read: $Mt = WL/28.5$. The line just before Equation 1 should have read: $Mt/2 = wL^3/57$.

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SOCIETY ORGANIZATION, GROWTH AND STATISTICS

BRIEF ABSTRACT OF PRESIDENTIAL ADDRESS DELIVERED BEFORE THE CANADIAN SOCIETY OF CIVIL ENGINEERS AT ITS ANNUAL MEETING LAST WEEK IN MONTREAL

By GEORGE HERRICK DUGGAN, Mem.Can.Soc.C.E., M.Am.Soc.C.E.
Vice-President and General Manager, Dominion Bridge Co., Ltd., Montreal.

THE Society was established February 24th, 1887, and incorporated 23rd June, 1887. The 30th anniversary of our foundation thus occurring this year, it may not be inappropriate to record some statistics of our growth and history, so that they are in convenient form for reference and in the hope that this history may be of assistance to the members in shaping our course for the future.

There is on fyle with the secretary a table showing for each year since the formation of the Society, the number of members in each grade, the total corporate membership and the total membership of all classes. Also, showing the number of members exclusive of students in each province with the percentage these numbers bear to the total membership exclusive of students of the Society for that year. The table is somewhat cumbersome to print and the accompanying charts have been prepared from it.

Chart No. 1 shows the membership each year in different classes. (NOTE: As this chart is practically identical, so far as the information it shows is concerned, with the chart published on page 46 of our January 18th issue, we are not reprinting it herewith.—EDITOR.)

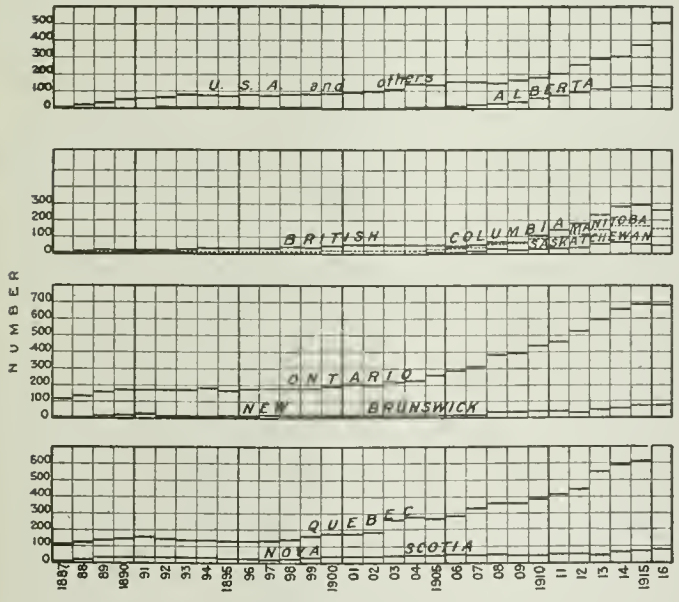


Chart 2.—Curves Showing Distribution of Members (Except Students) by Provinces.

Chart No. 2 shows the distribution by provinces of the members, not including students, for each year.

Chart No. 3 shows the percentage of corporate members in each province for each year.

Table No. 4 shows the date of formation of each branch and its membership each year thereafter to the present time; also the dates of formation of the provincial divisions now existing, with their present membership.

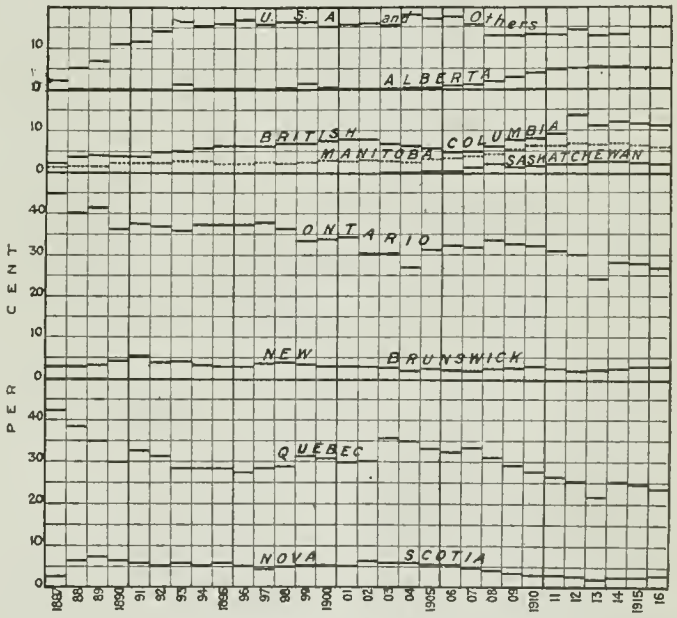


Chart 3.—Curves Showing Percentage Distribution of Members (Except Students) by Provinces.

Table No. 5 shows the geographical distribution of corporate members. The growth of the Society and the distribution of its members is apparent from the other charts and tables, but it seemed to me interesting to record the increase in membership in the larger eastern cities and by somewhat broader geographical divisions. I have therefore shown in Table No. 5 for the first year, 1887, the past year, 1916, and the intermediate year of 1902, the total corporate membership in column "A"; resident in Toronto, column "B"; in Ottawa, column "C"; in Montreal, column "D"; in the area bounded by lines roughly drawn around these three cities, "E"; in the somewhat arbitrary geographical divisions west of Port Arthur, "F"; from Port Arthur to Montreal, "G"; east of Montreal, "H"; with the percentage of the total corporate membership in each column for each year.

It will be seen that in 1887 the city of Montreal had 30.4% of the membership; the area shown in column "E," 65%; the district Port Arthur to Montreal, column "G,"

Table 4.— Branches in Order of Establishment and Membership Therein Each Year (Exclusive of Students).

Year Founded	Sydney 1905	Toronto 1906	Manitoba 1907	Quebec 1907	Ottawa 1909	Vancouver 1909	Kingston 1911	Victoria 1912	Calgary 1913	Edmonton 1914	Regina 1915	Total Branch Members	No. of Branches
1905	14	0	0	0	0	0	0	0	0	0	0	14	1
1906	15	58	0	0	0	0	0	0	0	0	0	73	2
1907	0	108	43	41	0	0	0	0	0	0	0	192	3
1908	0	142	64	44	0	0	0	0	0	0	0	250	3
1909	0	155	70	43	108	32	0	0	0	0	0	408	5
1910	0	154	91	51	140	45	0	0	0	0	0	481	5
1911	0	123	106	52	157	89	13	0	0	0	0	540	6
1912	0	152	124	56	183	108	11	58	0	0	0	692	7
1913	0	180	144	70	185	128	11	53	41	0	0	812	8
1914	0	192	175	75	197	137	21	53	51	44	0	945	9
1915	0	211	132	89	210	111	14	63	55	40	23	948	10
1916	0	200	141	89	221	117	15	65	48	42	28	966	10

80.5%, and the district west of Port Arthur, column "F," only 7.4%. In 1902 Montreal had dropped to 17.4%; the district column "E" to 36.7%; the district Port Arthur to Montreal to 34.7%, while the district west of Port Arthur had increased to 13.7%.

Comparing 1887 with 1916, Montreal has decreased from 30.4% to 17.4%; the district represented by column "E" from 65% to 36.7%, and the district Port Arthur to Montreal from 80.5% to 65.5.% The district east of Montreal has remained practically stationary, being 12.8% in 1887 and 11.9% in 1916, but the district west of Port Arthur has increased from 7.4% to 23.4%.

It will thus be seen that Montreal, on account of members alone, would naturally have been chosen originally as the headquarters of the Society, but there were additional considerations in that Montreal was also the headquarters of a number of large corporations employing engineers, and that it was conveniently reached by the majority of the membership at that time. Although Montreal's percentage of membership of the whole Society has dropped from 30.4% to 17.4%, it still easily maintains its lead in actual numbers over any other city, having 367 corporate members against 168 in Ottawa, which has the next largest number; it remains the head office of the large railway companies and of large engineering corporations, and it is only a few hours run from anywhere in district "E," still containing 36.7% of the membership; more convenient than any other large city to the eastern district containing 11.9% of the membership, and convenient to the district from Port Arthur to Montreal containing 65%. So that it may be said to have 77% of the membership tributary to it, and to all appearances it will continue to be the headquarters of the Society for a long time to come.

While there has been a large increase in the number of members in the district tributary to Montreal, there has been a much larger percentage of increase in the number of members west of Port Arthur so situated that they can only reach Montreal at much expense and with considerable loss of time. I think one would be pretty safe in saying that many Canadian engineers have never even seen the Society's building or know anything of the work of the Society beyond its publications and the activities of the local branch to which they belong. It is to be expected that members so situated should feel that they are best served as regards their daily work by their local associations, and have little interest or sympathy in the general work of the parent society as it exists to-day. My personal impression is that this attitude has increased largely of late. Its tendency under our present organization is to still further increase, and that, if we are to build up a strong national Society representing the whole profession in Canada, it is a factor to which most earnest consideration should be given.

The charter members, although so compactly situated, apparently foresaw the spread of our membership and made provision in By-law No. 31, now No. 54, for the formation of branches. The idea grew. It was discussed and encouraged in my early days on the council, and I was interested in the first branch formed at Sydney, N.S., when resident there in 1905, but, unhappily, that branch did not survive the stress of heavy and rapid construction work in which all of its members were engaged. It will be seen that in 1906 there were only two branches, one of which is not now in existence, with a total membership of 73, or 5.3% of the whole; while in 1915, the last year for which we have completely verified records, there were ten branches with a total membership of 948, or 31% of the whole.

Incidentally I may say that the Society and the council have not been inactive in providing headquarters worthy of the Society as it grew, in revising our by-laws, in altering the grades of membership as occasion arose, in providing for examination of candidates and generally in elevating the requirements for membership so that membership in the different grades might have a more definite meaning to the profession.

Table 5.— Geographical Distribution of Corporate Members.

Year	A Total Corp. Membership	B Toronto	C Ottawa	D Montreal	E Area inclosed in lines drawn around Toronto, Ottawa, Montreal	F District west of Port Arthur	G District Port Arthur to Montreal	H District east of Montreal
1887	251	18	37	76	163	18	201	32
		7.4%	14.8%	30.4%	65.0%	7.4%	80.5%	12.8%
1902	562	38	61	165	311	77	195	118
		6.8%	10.8%	29.5%	55.4%	13.7%	34.7%	21.0%
1916	2,120	153	168	367	777	495	1,383	252
		7.4%	7.9%	17.4%	36.7%	23.4%	65.5%	11.9%

In this connection it is interesting to note that in 1887 the members were 53% of the total membership; in 1897, 47.5%; in 1907, 26.7%; and 1916, 22.6%. Associate members in 1887 were 15.4%; in 1897, 25%; 1907, 37%; in 1916, 52.5%. Or, classing juniors with associate members, 57.8%. Summarizing, the percentage of members has dropped from 53% to 22.6%, while the percentage of associate members has risen from 15.4% to 52.5%.

In addition to the above, codes of ethics have been adopted and other internal changes made as required to keep abreast of our growth and the times. Legislation has been sought and obtained in some cases, whether that legislation has always been wise or not, it was nevertheless the desire of the majority of the members at the time, and, in either view, it now has little effect on the general activities of the members and may be left out of the discussion.

That ends my formal address. My further remarks are largely my personal opinions on the future conduct of our Society, are thus controversial and do not properly belong to a presidential address—indeed, it would perhaps be wiser to stop here on safe ground; but, in view of the interest now aroused in quickening our activities and enlarging our scope, the attention these matters are likely to receive at this meeting and the inability of the chair to take part in the discussion, I cannot let the opportunity go without making some comments and suggestions. I trust it will be understood I ask your further attention to my informal remarks to follow, only because of my deep interest in the welfare of the Society and the profession. I have had an active part in the management of its affairs for a long time, having served on the council for fifteen years starting in 1894, and have knowledge of many of the complaints, suggestions and acts of the Society during that period. In reference to one frequent complaint, I wish to say that I have not served on any council in that time of which the members who could attend have not been regular in attendance and have not given their best thought to every question that arose touching the welfare of the Society or the consideration of the applications for membership in whatever grade.

The statistics, showing as they do a very healthy growth in membership and apparently a widespread interest, if taken by themselves would seem to be cause for complacency and a feeling that all is well. We know, however, from the many complaints, that most of our members are far from satisfied, and I feel myself that we have only made a start towards organizing our forces to advance our profession to that position in public estimation to which the engineer is entitled.

We may first inquire of what benefit the Society can be to its members and what it is now accomplishing. It seems to me the benefits to be expected are of two kinds: First, what might be called the internal benefits within the profession, such as the professional standing amongst ourselves, conferred by membership; the advancement of professional knowledge by the reading and discussion of papers and the work of technical committees; the acquaintances and friendships brought about by meetings, conventions and other Society activities; and some advantages to its members in finding employment and advancement resulting from the above.

The other class of benefits we might call external, broadly covered by the proper recognition of the profession of the engineer by the public, including the proper appreciation of the engineer's services on engineering questions, and the further recognition by the public that the engineer by his training and attainments should be eminently fitted to take his place in public affairs and that he should be sought as an adviser in questions not only of engineering, but as well on other important matters where his engineering training and standing qualify him to give sound advice on affairs not directly related to the practice of his profession. The latter feature, under many different headings and in different ways, has been the subject of a number of addresses and discussions amongst our neighbors in the United States and the technical press has made several references to success attending this movement.

In my view we should strive for all these benefits both internal and external, but we cannot hope to attain full success in our quest for external benefits until we have put our house thoroughly in order and so organized our institution that we realize the internal benefits to the greatest extent possible, and I wish therefore to make a few suggestions as to improvements that seem within our immediate grasp.

It seems to me important to have some arrangement by which the considerable portion of our membership far removed from headquarters can keep in touch with the work of the Society and can take its share of directing that work. It is true that every member now receives a report of proceedings at the annual meetings, such transactions as our limited funds enable us to print, and most of the members belong to some local branch or division where matters of more or less general interest come up for discussion and which sends in a report once a year to be distributed to all of the members of the Society. This, however, is long-range work—in many cases divested by elapsed time of its interest, and there must be many who would be glad to take an active interest and discuss our affairs from time to time as they arose, as does the Central Council, but who do not care to give the time to put their views in correspondence—indeed, there is little opportunity for any one to do so.

I think some plan should be devised by which there should be a special meeting of the council at least once a year, preferably twice, to discuss the more important affairs of the Society. If it is not feasible to bring the whole council together, delegates could be sent from the provincial divisions where these exist, and arrangements could be made to nominate a councillor to represent a district where a division has not yet been formed. It seems to me that in an organization such as ours, meeting in general convention only once a year and properly limited in its actions as to changes in by-laws and the general conduct of affairs so that these can only be brought about by slow and elaborate process, it is necessary to leave much to the direction of the council. For, while the discussions that take place at these annual meetings are most valuable, little action can result from them except as it is worked up in detail by the council, and I think important affairs should be discussed and determined by more of the council than can possibly attend the ordinary meetings.

Many of our councillors resident in Ottawa, Quebec and Toronto sometimes attend the regular meetings, but it must be a tax to come even this distance and it cannot be expected that councillors will come from a greater distance unless by special arrangement and when there are definite important matters to discuss. The experiment of a conference was tried two years ago with some success, but there is not adequate machinery in existence to continue the good work started and the finances of the Society have not permitted the expense of calling subse-

quent conferences to consider arrangements for this and other activities.

Presentation of papers and the exchange of professional experience and thought has often been referred to as one of the most important functions of our Society, as it no doubt is. Our shortcomings in this respect have been deplored in annual meeting and have been referred to in several presidential addresses but no substantial improvement is visible; indeed, we have rather deteriorated in the number of papers per member. I think it may be taken as a truism that the value of a paper both to the writer and to the members is very largely enhanced by the discussion thereon and that oftentimes the discussion brings the writer into prominence far more than his original communication, besides giving other members interested a wide range of thought and experience upon the subject. My impression is that by-law No. 48 is seldom lived up to and that with our present haphazard arrangements, interesting and valuable papers are often read at the branches that never reach the publications of the Society, and if they do the discussion that took place on their presentation seldom accompanies them. Even at headquarters the papers are seldom presented sufficiently in advance to get the discussion they deserve.

There have been interesting articles contributed by our members to the engineering press that would have enhanced the value of our transactions had they first been read and discussed before the Society, and still might later have found their way to the wider publicity of the technical press.

We have probably lost these papers through the feeling that papers presented to the Society are frequently long delayed before publication and often are not published until they appear in the semi-annual volume. I think it will be agreed that the present procedure almost consigns a paper to oblivion, because few will read all the transactions en bloc when received in a large volume.

I feel confident that our transactions could be greatly improved by a more prompt observance of the procedure laid down in by-law No. 48, with the addition of arranging that every paper accepted as worthy to be published in the transactions be first issued in time to permit every member interested to submit a written discussion if he is unable to be present at the reading of the paper.

It is easy to suggest improvements in our service where it now falls so far short of what we all feel it should be, but it is difficult to see how any substantial improvement can be accomplished on our present revenues. A consideration of the balance sheets for several years past shows our revenue dangerously near our expenditure. It is true that this year we have an apparent surplus of revenue of about $3,600, but this includes entrance fees, and it must be considered that an exceptional effort to collect arrears has been made for the past two years, that the reservoir of arrears has been heavily drawn upon and will not always be available to make up what might otherwise be a deficit. Moreover, in anticipation of a lower revenue than was actually received, the Finance Committee pared the appropriations to the very lowest limit and the service to our members has been much curtailed. Again, all expenses are rapidly increasing and, through the growth of that very necessary part of our organization, the branches, the amount returned to the branches is becoming a heavy tax,—last year having amounted to $2,400.

From an experience gained through an active interest in the Finance Committee for some years past, I believe the Society is being administered economically with the exception perhaps of the collection of arrears. Arrears has been a subject of serious consideration and is too long to discuss here. I think we may assume, however, that to deal with these too strictly will result in loss of members, in some hardship, and that our average revenues over a period of several years would not be sensibly increased.

In my view the members are now getting practically all of the service they can expect from the funds at the disposal of the Council. In other words, if better service is required, it must be paid for.

If our members realize, as I am sure they will, that increased revenue is necessary to give the service that should be rendered by a national society to its members and to the profession it represents, I am confident means will be found to provide the revenue without asking appreciable sacrifice on the part of the members. Possibly it would mean some reduction in the total roll, but those who could not afford to pay would still benefit by the more rapid elevation of the engineer and the general *esprit de corps* engendered in the profession.

I don't think we should ask students or juniors to pay any increased fees because the benefits these grades receive from the Society probably do not extend beyond its publications and the friendships formed through its meetings; also because as a class they are probably not able to afford a larger subscription. But, as a man rises in his profession to the grade of associate membership, he no doubt receives additional benefits and he should, under ordinary circumstances, be able to afford a larger annual subscription. A full member has, we may assume, attained that position in his profession and in the community where any reasonable increase in his dues would be of little financial embarrassment to him and, if the Society is performing all its functions, he should be realizing in addition to the internal benefits some of the benefits to be expected from the recognition of the engineer by the public both in his profession and in public affairs.

I would therefore suggest that members and associate members resident at headquarters who, from their situation, have the use of the building and library and of the clerical staff in conducting their meetings, should pay larger dues for these privileges—the increase for the associate members to be comparatively small and for full members to be of a very considerable amount, to bring their dues more nearly in accord with those paid by resident members of the American Society of Civil Engineers for equal privileges.

Again, I think the general funds of the Society should not, under the difficulties that now confront us, be devoted to the up-keep of branches beyond the work which is of a general society nature, such as the publication of reports, the actual clerical work of communicating with headquarters, the payment of delegates' expenses and affairs of a similar kind, leaving all local assessments by the branches or divisions to be made as each may determine for itself.

Reference has been made to the important work expected from the Society in the influence it should exert outside its immediate membership. This seems to be our real goal, because until governing bodies, corporations, financiers and promoters can be made to realize that success or failure of an undertaking so often depends on the quality of the engineering advice it receives, the value of that advice will not be properly appreciated; and when the public takes the larger view, to which I have referred, and seeks engineers' advice on other than strictly engineering questions, we will have approached

that position which will bring the proper standing and emolument to the members of our profession. It is comparatively a new field for concerted action, and, in consequence, it does not seem practicable to lay down any definite course that will land us at the goal. It would seem to be rather a case of seizing every opportunity that offers, either to the Society or to the individual, to work for that end.

Publicity of the proper kind is undoubtedly very important, and the action of those members in the Calgary branch, and of the committee of rate-paying engineers of Montreal, who gave much time and labor without compensation in a public service, should do much for our cause, and is an example of unselfish work for the general good to be highly recommended to those who may have similar opportunities put in their way. Quite recently our past president, Mr. Tye, has presented a paper requiring a large amount of thought and labor upon a most important public problem. I am sure one of Mr. Tye's rewards will be the knowledge that he has brought the whole profession prominently before the public.

It must not be thought from the foregoing I am insensible to the public recognition already accorded to members of our profession. We were proud at the last annual meeting to congratulate three of our members who had been honored by knighthood for distinguished engineering and public services, and we know that other members are on important public commissions.

Abstracts from Branch Reports, Can. Soc. C. E.

QUEBEC

MEETINGS have been held as usual during the year. Great interest has been taken in the outcome of the society's efforts to have the principle of the employment of Canadian engineers by the Canadian government recognized and adhered to, and also in the results of the progress made by the Committee on Society Affairs appointed at the last meeting.

The newly elected officers are as follows:—

Chairman, A. E. Doucet; secretary, W. Lefebvre; members of branch council, A. R. Decary, J. E. Gibault and Altheod Tremblay.

TORONTO

THE Toronto branch had a fairly successful year in spite of the very unusual conditions caused by the war, approximately one-third of our total membership having enlisted for service overseas. During the year we added about 25 new members. We now have on our lists 50 members, 120 associate members, 30 juniors, 6 associates and 84 students.

We held nine evening meetings and one afternoon excursion to a work of engineering interest (the Toronto Filtration Plant).

One of the evening meetings took the form of a smoker and in others we endeavored to depart from the purely technical, and had subjects for discussion of more popular interest, the average attendance being forty-two.

At the beginning of the year committees were formed to work upon specifications and subjects looking to the advancement of the profession.

We have already forwarded to council the report of our Committee on General Clauses for Specifications, upon which a great deal of careful work was done. At the present time we have no other reports available for presentation.

The financial statement for the year shows a balance on hand of $187, receipts for the year being $342 and expenditures $380.

The following officers were elected on January 11th for the year 1917:—

Chairman, E. W. Oliver; secretary-treasurer, L. M. Arkley; executive, H. G. Acres, A. H. Harkness, E. G. Hewson and T. T. Black. The retiring chairman, G. A. McCarthy, also acts as a member of the executive.

OTTAWA

THIS branch has had one of the most successful years of its history. By the practice of every possible economy consistent with efficiency, by doing without permanent headquarters, by confining our activities within reasonable limits of expenditure, we find ourselves at the close of 1916 out of debt and with a credit balance of about $200.

Although we are still without permanent quarters we have had no trouble in making suitable arrangements for our evening and luncheon meetings. The Normal School auditorium, the board room of the Conservation Commission and the assembly room of the Public Library have always been at our disposal.

While it is considered exceedingly important from the point of view of the profession that our own members should be induced to relate their engineering experience and share with their fellow-members their practical knowledge of engineering difficulties and in the handling of men, we have felt that during the war it would be more fitting if we confined our papers and discussions to topics of a more popular and general nature which would be of timely and particular interest to the profession.

With many of our members overseas and most of the others, in their various capacities, carrying on extra work to assist the government in the present crisis, we have felt that there would be very little time for evening meetings for serious technical dissertations and discussions. We have, therefore, concentrated our effort on informal gatherings with a view to getting better acquainted with one another, with the affairs of the society, and with problems of general interest to the engineering profession.

We have been exceedingly successful. Ottawa engineers know one another to-day as they never did before. There has been a marked increase of interest in society

affairs, not only among members of the branch, but among non-members; and—very important—as a result of our activities during the year, there has been a very notable development of esprit-de-corps, and it is felt that the prestige of the engineering profession has been enhanced. One of the most potent influences in this connection has been our luncheon meetings, particularly the occasion of the address by the Rt. Hon. Sir Wilfrid Laurier on "The Engineer in Canada."

One of the greatest influences for developing general interest in society affairs has been the efforts of the Ottawa members of the Committee on Society Affairs, who have, by their carefully conscientious efforts to obtain the thought of the members of the branch respecting society affairs undoubtedly developed an intelligent active interest in our society which has not existed in the past, at any rate among the rank and file of the branch.

The branch arranged for a special qualifying course for officers in the Engineers, which was held during the months of February, March, April and May. The classes, which required a part of two afternoons and two evenings a week, were particularly well attended. While they were under way, the managing committee felt that it would not be wise to arrange for other meetings. During this period, however, the branch, at the request of the Sportsmen's Patriotic Association of Ottawa, arranged for a Sunday evening patriotic concert in the Dominion Theatre, which proved to be a very great success.

The meetings held during the past twelve months were as follows, all being luncheons excepting the first two mentioned:—

January 17th, Organization of Military Engineering Classes; January 21st, G. R. G. Conway, "The Engineer and Standards of Beauty"; January 13th, Dr. Adam Shortt, "The War and the Engineer"; E. A. Dunlop, M.L.A., "Trip to the Battle Front"; April 13th, Lieut.-Col. Melville, "With an Engineering Battalion at the Front"; October 19th, Prof. B. Bakhmeteff, "The Russian Engineer and the War"; November 23rd, Sir Wilfrid Laurier, "The Engineer in Canada."

In the last annual report reference was made to two amendments to the branch by-laws, which have subsequently been formally approved by letter ballot and put into force. The first provided for the enlargement of the managing committee to include the past chairman and past secretary for one year following their term of office, and the sitting members of council within the jurisdiction of the branch during their term of office. The change has provided for easy and direct communication between the executives of the main society at Montreal and of the branch. It has furnished continuity of direction of branch affairs between successive managing committees. Furthermore, it has made available to the branch the benefit of the considered judgment of members best qualified to advise and assist.

The second amendment provided that the fiscal year of the branch should be the same as that of the main society. From its organization in 1909 our branch year has remained from October to October. The change enables us to report to the main society for the same period for which the main society affairs are reported at the annual meeting.

A special effort has been made by our membership committee to induce worthy members of the profession to enter the society. Excellent results have been realized, fourteen new members being added.

The branch membership figures for 1914, 1915 and 1916 are given hereunder:—

	1914.	1915.	1916.
Honorary members	3	1	1
Members	46	51	60
Associate members	113	124	124
Associates	1	1	1
Juniors	28	33	36
Students	16	27	28
Ottawa associates	21	17	23
	228	254	273

Fifty-one of our members have enlisted for overseas.

The library and records of the branch have been placed in one of the most convenient office buildings of the city, and a librarian appointed. During the past year many important additions have been made to the library. Special efforts are now under way for indexing and classifying the lantern slides in the possession of the members and those which are in the possession of government offices but under the direction of members. Efforts are also being made to secure photographs or records of historical interest to the engineering profession.

The annual meeting of the branch was held January 11th, when the following officers were elected: Chairman, Alex. Gray; secretary-treasurer, J. B. Challies; Managing Committee—Gordon Gale, A. T. Phillips, W. F. M. Bryce, S. J. Fortin and J. H. McLaren.

REGINA

THE arrangement entered into with the Regina Engineering Society to hold alternate meetings every first Thursday has been satisfactorily maintained. Ten joint meetings were held, five of which were presided over by the Regina branch, Can.Soc.C.E. There were also a number of executive and business meetings held by the branch itself.

Amongst the papers read were:—

"Reminiscences of an Old Surveyor," by Cyrus Carrol.

"Terminal Elevator Construction," by C. D. Howe.

"From Conception to Completion—the Western Railroad," by J. N. deStein.

Our membership comprises 7 members, 19 associate members, 2 juniors and 2 students. Total, 30—an increase of five over the previous year. Eleven are on active service.

During the year sixty dollars was received in rebates from the parent society, and a balance of twenty-six dollars is on hand.

The Regina branch, supported by all members of our society in this province, propose to extend its scope and form a "Saskatchewan Branch of the Canadian Society of Civil Engineers." We hope at the next annual meeting to be able to present a very satisfactory statement of this new subdivision of our society.

At the annual meeting, held December 4th, the following officers were elected: Chairman, L. A. Thornton; vice-chairman, W. R. Harris; secretary-treasurer, J. N. deStein; executive, E. G. W. Montgomery, R. J. Lecky and (ex-officio) O. W. Smith; auditors, D. A. R. McConnell and H. R. Mackenzie.

MANITOBA

THE present membership of the branch is as follows: Members 37, associate members 83, juniors 21, students 29, local associates 54. Total, 224.

Eight meetings of the general section were held during the year at which the average attendance was thirty-two.

Eight meetings of the electrical section were held with an average attendance of thirty-two.

Three meetings of the mechanical section were held with an average attendance of forty-five.

The treasurer's report shows a credit balance of $440.

The annual meeting of the branch was held December 7th, and the following officers were elected for the year 1917:—

Chairman, W. L. McKenzie; executive committee, J. C. Holden, H. W. McLeod and M. V. Sauer; auditors, B. S. McKenzie and T. L. Roberts; secretary-treasurer, A. W. Smith.

EDMONTON

THE branch now comprises forty-five members, as follows: Members, 7; associate members, 29; associates, 1; juniors, 6; students, 2; total, 45.

Nine members are absent on active military service and others on other war service, consequently the average attendance was below that of the previous year.

The meetings were of an informal nature and were held monthly on the third Wednesday. Usually a paper was read, followed by discussion.

In February we had the privilege of entertaining F. C. Gamble, past president Can.Soc.C.E., at a banquet in the Macdonald Hotel.

The question of the employment of alien engineers on government work was taken up along the lines suggested by headquarters.

A provincial division was formally constituted by council, and negotiations in connection with the formation of this division are now being carried on with the Calgary branch.

The following meetings were held during the year 1916:—

January 19th, "The Individual Responsibility of Members of the Profession," by W. R. Smith; February 9th, Banquet to Mr. Gamble; February 16th, "Development of the Mountain Park Coal Fields," by N. M. Thornton; March 24th, "Panama-Pacific Exposition," by Prof. J. A. Allan; May 10th, Informal Dinner; November 3rd, Informal Dinner; November 15th, "Geological Problems of the Petroleum Resources of Alberta," by Prof. J. A. Allan; December 20th, "Past and Present Methods of Coal Mining," by N. M. Thornton.

The election of branch officers is held in May, those elected taking office the following October and remaining in office one year. The fiscal year closes in October. The election of officers for the season 1916-17 was as follows:—

Chairman, L. B. Elliot; vice-chairman, J. Chalmers; secretary-treasurer, C. A. Robb; executive, A. T. Fraser, J. L. Cote, D. J. Carter and D. Donaldson.

J. Chalmers and C. A. Robb resigned to take up duties with the Imperial Munitions Board, so J. D. Robertson was then elected as vice-chairman, and A. W. Haddow as secretary-treasurer.

CALGARY

DURING the past year there were four general business meetings of the branch, including the annual meeting in December.

The executive committee held ten business meetings, and the Committee on Credentials and Applications held two meetings.

Four dinners were given during the winter, and the branch was entertained by five speakers, as follows:—

January 13th, A. J. Graves, "Administration of Public Utilities"; February 3rd, C. D. Howe, "Government Elevator Construction"; February 24th, Dr. J. G. Rutherford, "Some Thoughts on the Present World Situation". (Ladies' Night); March 16th, G. N. Houston, "Legislative Control of Engineering Practice"; March 28th, H. B. Muckleston, "Electrical Illumination of Panama-Pacific Exposition."

A statement of the finances on November 30th showed a balance of $326.

The present membership of the branch is made up as follows:—

Members, 13; associate members, 30; juniors, 5; students, 1; local associates, 10; total, 59.

Nineteen members have enlisted for active service, two of whom were killed in action, and one is missing.

The following officers were elected for the ensuing year:—

Chairman, A. S. Dawson; secretary-treasurer, Sam. G. Porter; executive committee, H. Sidenius, M. H. Marshall, C. M. Arnold, and (ex-officio) F. H. Peters and William Pearce; auditors, J. S. Tempest and S. K. Pearce.

VANCOUVER

DURING the year six papers were read, as follows:— June 6th, "Some Remarks on Railway Location Problems in British Columbia," C. E. Cartwright; January 27th, "Vancouver Grain Elevator," C. D. Howe; February 1st, "City of Kamloops Power Plant and Pumping Station," H. K. Dutcher; March 2nd, "The Prince Rupert Drydock of the G.T.R.," Mr. Pillsbury; March 23rd, "The Bridges on the C.N.P. Railway," J. L. Harrington; April 13th, "Pneumatic Foundations," E. G. Matheson.

On September 25th a deputation from the branch interviewed Sir George Foster, asking, for the society, the support and recognition of the Dominion government and expressing the hope that one day the Dominion government would recognize and consult with the society on national engineering questions in the same way that the governments of Great Britain and the United States recognize and consult with the Institution of Civil Engineers and the American Society of Civil Engineers.

Arrangements have been made with the University Club, Vancouver, whereby the members of the society have the use of the club reading-room.

No papers have been arranged for the coming season as so many members are overseas.

VICTORIA

NINE meetings were held during the year, with an average attendance of twelve. Six papers were read and discussed, as follows:—

E. Davis, "Rules and Regulations of British Columbia relating to Annual Rental of Water Powers"; C. E. Fowler, "Architecture of Bridges"; R. F. Hayward, "Mexican Light and Power Company's Development"; W. Young and W. C. Smith, "Domestic Water Supply of Greater Vancouver"; D. O. Lewis, "Marine Wood Borers"; Dr. Plaskett, "Construction of New Dominion Observatory and Telescope on Little Saanich Mountain, Victoria."

Three applicants were elected branch associates, of whom two are now corporate members of the society.

Three corporate members and three branch associates have joined the overseas forces during the past year, bringing our known total up to twenty-five in the C.E.F., and of this number two corporate members have been killed in action during 1916.

The membership of the branch stands as follows:—

Members, 24; associate members, 33; juniors, 8; students, 1; branch associates, 9; total, 75, showing a decrease of four compared with last year's total.

The following officers were elected for 1917 at the annual meeting, held December 13th:—

Chairman, D. O. Lewis; vice-chairman, R. A. Bainbridge; treasurer, E. Davis; secretary, R. W. Macintyre; other members of executive, E. G. Marriott, C. Hoard and (ex-officio) F. C. Gamble and H. W. E. Canavan; auditors, Lewis W. Toms and J. B. Shaw.

CANADA'S RAILWAY PROBLEM AND ITS SOLUTION*

OUR RAILWAYS SHOULD BE MORE CONSOLIDATED — LEAVE THE CANADIAN PACIFIC AS IT IS AND FORM NEW PRIVATE CORPORATION TO TAKE OVER C.N.R., G.T.R., G.T.P. AND TRANSCONTINENTAL

By WILLIAM FRANCIS TYE, C.E.,
Formerly Chief Engineer, Canadian Pacific Railway Co.

After a great deal of study of Canada's railway problem, the writer of this paper has arrived at the following conclusions:—

1. The National Transcontinental, the Grand Trunk Pacific and the Canadian Northern railways are unable to earn their operating expenses and their fixed charges. Canada has built, and is operating, the first of these roads, and Canada and the various provinces have guaranteed the principal and interest of most of the bonds of the other two. As the roads are unable to earn their fixed charges, they must, of necessity, be paid by the country.

2. The failure of these roads is due to the duplication of lines by all the railways, encouraged and bonused by the government; to the excessive cost of the Grand Trunk Pacific and National Transcontinental railways; to the failure of the Grand Trunk Pacific to provide itself with an adequate system of feeders in the west, and to the construction, by the Canadian Northern, of the long and unproductive stretches of road across British Columbia and Northern Ontario, without feeders, terminals, etc.

3. If the Canadian Northern, the Grand Trunk Pacific and National Transcontinental be maintained in two separate systems, it will cost at least $400,000,000 to build the necessary branch line feeders and terminals, to provide them with adequate rolling stock, and put them in proper physical condition to compete with the Canadian Pacific.

4. It will be necessary that the Grand Trunk Pacific build five to six thousand miles of feeders in the west.

5. It will be necessary that the Canadian Northern build two to three thousand miles of feeders in the east, and terminals costing many millions in Montreal, Toronto, Ottawa, Quebec and Vancouver.

6. Canada has already sufficient railway mileage for years to come. The additional mileage necessary for these roads could only be had by duplicating existing lines. Such duplication of lines would only add to the burden to be borne by Canada in the way of subsidies, guarantees, etc., without doing the country any good.

7. Canada has sufficient railway mileage and traffic for two good transcontinental systems—the Canadian Pacific and another—but not enough for three.

8. A consolidation of the Grand Trunk, the Grand Trunk Pacific, Transcontinental and Canadian Northern railways would give a well-balanced system. The Grand Trunk has an excellent system in the east, with terminals in all large and important centres; the Canadian Northern has not. The Canadian Northern has a good system of feeders in the west; the Grand Trunk has not. Each is strong where the other is weak. Combining them must, of necessity, be the most economical and efficient way of handling the situation.

9. Such a combination would not require more than $100,000,000 to provide it with sufficient rolling stock and to put it in proper physical condition to compete with the Canadian Pacific.

10. The saving in capital cost would be at least $300,000,000 and, at present rates of interest, the saving in fixed charges, at least $15,000,000 per annum.

11. The Transcontinental cost $100,000 per mile to build. The parallel Canadian Northern cost less than $50,000 per mile, and is, in every way, as efficient an instrument of transportation. The Quebec bridge, with approaches, will cost $40,000,000, and will not be necessary for many long years to come.

12. The Transcontinental, including the Quebec bridge, has cost Canada at least $100,000,000 more to build than it would have cost the Canadian Pacific to build as efficient a road.

13. Including operating expenses and fixed charges, it costs the Canadian Pacific about $70 to do $100 worth of business. Including operating expenses and interest on cost, it costs the Intercolonial and the other Canadian government roads from $200 to $220 to do $100 worth of business.

14. Canada should follow the wise example set by Sir John Macdonald when dealing with the Canadian Pacific in 1879-80, and form a new private corporation, with sufficient power and the necessary safeguards, to take over and consolidate the Grand Trunk, Grand Trunk Pacific, Transcontinental and Canadian Northern railways, and develop another Canadian Pacific, rather than to have the government take

*Abstract of paper presented to the Canadian Society of Civil Engineers at Montreal, January 18th, 1917.

them over and develop another and a vaster and more expensive Intercolonial.

15. Conditions for the formation of such a company are much more favorable than they were in 1880, as western Canada had not then been proven, as it since has been, to be capable of supporting a large and prosperous population.

16. Such a combination would start with gross earnings of at least $100,000,000 per annum, with a probable average increase of 8 per cent. per annum, and probable net earnings of from $25,000,000 to $30,000,000 per annum, and a net revenue from other sources of about $2,800,000.

17. Its fixed charges at consolidation would be about $35,000,000, and it would be under the necessity of spending, in the first five to seven years, at least $100,000,000 to provide rolling stock and to put its properties in good physical condition.

18. Deficits for some time to come would be inevitable, owing to the heavy fixed charges amounting to about $35,000,000, as compared with $10,300,000 per annum for the Canadian Pacific.

19. As these high fixed charges are caused by the excessive cost of government construction and by duplication of lines, bonused and guaranteed by the government, Canada must pay them.

20. The fixed charges would be at least $15,000,000 less with one private system than with two, and very much less with private than with government management.

21. With such a combination as has been outlined, the series of deficits should not last more than five to ten years, after which the road should be very successful.

22. In order to control its policy, and to share in its certain prosperity, Canada should have an interest in the new company. The Dominion government should furnish 40 per cent. of the money required, own 40 per cent. of the stock, and appoint 40 per cent. of the directorate, but take no part in the actual management. This would give all the advantage of government control without any of the manifest disadvantages of government management.

23. Once this combination was successful, Canada should once and for all abandon the vicious policy of bonusing railway construction, either by gifts of money or land, or by the still more vicious policy of guaranteeing the bonds of railway companies of which it has no direct control.

The reasons for arriving at the foregoing conclusions are set out as follows:—

Canadian Railway Problem.—The Canadian railway problem is mainly connected with the Transcontinental railways. The Canadian Northern and Grand Trunk Pacific Railway Companies have reached a point where it is not possible for them to pay their fixed charges, or to finance their obligations. As the various Canadian governments have guaranteed the greater portion of the bonds sold to provide money for their construction, it is necessary for the government to either take them over, very largely aid the companies, or find some other method of solving their difficulties. The National Transcontinental, built and operated by the government, does not earn operating expenses, let alone fixed charges.

Financial Conditions of the Railways.—In order to arrive at a clear understanding of the problem, it is first necessary to briefly set out the financial situation of each company concerned.

Canadian Pacific.—The Canadian Pacific extends from St. John, N.B., on the east to Vancouver on the west. Its mileage is made up of:—

Main Line, Montreal to Vancouver	2,899 miles
Other lines, branches, etc.	10,094 "
Total	12,903 "

The annual report for the year ended June 30th, 1916, shows the following financial results on its operation for the year:—

Gross earnings	$129,481,885
Working expenses	80,255,965
Net earnings	49,225,920
Fixed charges	10,306,196
Surplus	38,919,724
Surplus revenue	36,871,435

In addition it had:—

Other income	$ 9,940,964
Making the total available for dividends	46,812,390

Grand Trunk System.—The Grand Trunk system extends from Quebec and Portland on the east to Chicago on the west, and to North Bay on the north.

Its mileage consists of:—

Miles of roadway	4,792 miles
Second track	1,060 "
Total	5,853 "

The annual report for the year ended December 31, 1915, shows the following results for the system:—

Gross receipts	£10,379,493
Working expenses	8,289,476
Net traffic receipts	2,090,017
Net revenue	2,540,701
Total fixed charges	2,030,017
Surplus for year	510,684
Equivalent to	$ 2,487,031

Grand Trunk Pacific.—The Grand Trunk Pacific extends from Winnipeg on the east to Prince Rupert on the west. Its mileage consists of:—

Main line	1,746 miles
Branches	1,009 "
Total	2,755 "

The financial results of its operation for the year ended June 30, 1915, as shown by Railway Statistics of the Dominion of Canada, were as follows:—

1915.

Gross earnings	$6,660,584
Operating expenses	7,383,665
Operating loss	723,081
Total net loss	626,940
Fixed charges	6,385,604
Which would make total loss for year	7,012,544

In the Railway Statistics, from which the foregoing were taken, the fixed charges of the Grand Trunk Pacific (alone of all the private-owned roads) are not given. The bonds outstanding for the year ended June 30, 1915, are given as $168,405,710.

It is understood that of these outstanding bonds £7,200,000 bear 3%, the balance 4% interest, which would make the fixed charges as shown.

National Transcontinental Railway.—The National Transcontinental Railway extends from Moncton on the east to Winnipeg on the west. Its mileage consists of:—

Main line	1,799 miles
Branches	194 "
Total	1,993 "

The road has only been operating from Moncton to Winnipeg a little over a year, and the financial results of its operation, for the year ended June 30, 1916, have not as yet been published.

It is believed that its gross earnings are about $6,000,000, and that its operating expenses are in excess

of its gross earnings, making a total loss for the year about $6,000,000.

Fixed charges of government-owned railways are not given in the Dominion statistics. They were arrived at in the following manner:—

The Stanton-Gutelius report shows the cost of the Transcontinental to be	$180,000,000
Figuring interest on this sum, and adding the deficits year by year shows the cost of the Transcontinental, exclusive of equipment, to be, in 1916	191,068,400

Interest at 3%, (the rate required by the Act), on this, amounts to $5,732,052, which is, therefore, taken as the fixed charges.

Intercolonial.—The Intercolonial extends from Halifax on the east to Montreal on the west, and is owned and operated by the Dominion of Canada. Its mileage consists of:—

Main line	797 miles
Branches	694 "
Total	1,491 "

The financial results of its operations for the years ended June 30, 1913 and 1915, were as follows: all figures, except interest on cost, being taken from the Dominion Railway Statistics.

1913.

Gross earnings	$12,349,296
Operating expenses	12,510,312
Operating loss	161,016
Interest on cost to date	13,160,803
Which would make total loss for year	13,321,824

1915.

Gross earnings	$11,259,710
Operating expenses	11,348,756
Operating loss	89,046
Other income	180,778
Operating income	91,732
Interest on cost of construction to date	14,485,929
Which would make total loss for year	14,394,197

The cost of construction, including interest, not being given for government roads, this cost was taken from a series of most admirable articles on the Intercolonial, written by Mr. Samuel O. Dunn, editor of the "Railway Age Gazette." Mr. Dunn shows the actual cost, including interest, of the Intercolonial, was as follows:—

1912	$314,061,270
1913	329,020,209
1914	348,089,518

On the same basis the cost in 1915 would be:—

1915	$362,148,221

Interest at 4% which Mr. Dunn estimates is the average paid by the Intercolonial, amounts to:—

1913	$13,160,808
1915	14,485,929

Canadian Northern.—The Canadian Northern extends from Quebec on the east to Vancouver on the west and has, in addition, a small disconnected system in Nova Scotia.

As shown in the Railway Statistics it had, in 1915, a mileage of:—

Main line	1,177 miles
Other lines and branches	6,766 "
Total	7,943 "

It had, at that date, under construction, 1,538 miles of line, making its present mileage 9,481 miles.

The annual report shows the financial results of its operations for the year ended June 30, 1916, to have been:—

Gross earnings	$35,476,275
Operating expenses	25,244,187
Operating revenue	10,232,088
Operating income	9,490,580
Fixed charges	10,391,163
Net loss	900,583

The foregoing shows a net loss of a little over $900,000. It is, however, believed that the road has large floating liabilities, and at the date at which the foregoing statistics were submitted, that many miles of newly constructed lines had not as yet been taken into the system, and when its finances are put on an operating basis, that its fixed charges will be materially larger. In the following discussion it is assumed, that re-organization of its finances and completion of construction, will add $3,000,000 to its fixed charges, making them $13,400,000 per annum, but, at this date, no figures are available to prove, or disprove this assumption.

From the foregoing it will be seen that the Canadian Pacific has been a great financial success. The Grand Trunk has been a moderate financial success. The Canadian Northern has been a financial failure; and the Transcontinental, the Grand Trunk Pacific and the Intercolonial have been great financial failures.

The problem which now confronts Canada is to find a remedy for the unsatisfactory state of affairs shown by all the roads, except the Canadian Pacific.

(To be continued in the next issue.)

EXPORTATION OF ELECTRICITY.

An unusually interesting and instructive article on "The Exportation of Electricity from Canada," appeared in *The Canadian Engineer* of January 11th. This article was from the pen of Mr. Arthur V. White, consulting engineer to the Commission of Conservation, Canada, and to the International Joint Commission, Ottawa and Washington—Lake of the Woods investigation. It originally appeared in the recent annual number of *The Monetary Times* and on account of its great value was reproduced in these columns. In the republication of the matter a portion of one of the paragraphs was inadvertently omitted. This paragraph should read:—

In 1891, Mr. E. B. Borron, in making his report to the Ontario government on the lakes and rivers, water and water powers of the province of Ontario, drew special attention to the fact that Ontario has no true coal. Mr. Borron stated:—

"Thus it will be seen that in respect of fuel and consequently of steam power, Ontario occupies on this continent a very unfavorable, one might say, unenviable position, as compared with the maritime provinces and British Columbia, and with many, if not most, parts of the United States, and still worse as compared with England, Belgium and other great manufacturing countries in Europe. As was well said in The Monetary Times a few days ago, 'Ontario has to import her motive power, and the Dominion commits the folly of taxing it.' To which might have been added, 'with the possibility of being denied even that poor privilege, should at any time commercial intercourse with our neighbors to the south be suspended or interrupted.' "

CANADIAN SOCIETY OF CIVIL ENGINEERS

REJUVENATION, RESEARCH AND RECOGNITION WERE THE MAIN TOPICS OF DISCUSSION AT THE THIRTY-FIRST ANNUAL MEETING IN MONTREAL LAST WEEK.

RESEARCH of importance has been and is being done by members of the Canadian Society of Civil Engineers. But far more research work must be done to aid in winning the war and, especially, to settle satisfactorily the many difficult problems to be met after the war. Through these research activities the Society will be brought into contact with national affairs and those who direct them, and thus will come RECOGNITION, the pinnacle toward which the profession in Canada has struggled continuously for thirty years past. But to make research effective and recognition certain, REJUVENATION must come first,—rejuvenation of individual effort, interest and enthusiasm on the part of every member.

That sums up the trend of thought of the civil engineers who attended the thirty-first annual meeting of the Canadian Society of Civil Engineers at Montreal last week. Those sentiments were directly or inferentially reflected in almost every speech made at the meeting. "Rejuvenation, research and recognition" might be said to have formed the slogan of the members.

Great interest was exhibited throughout the three business sessions. Everyone was "up on his toes." Feeling ran strong, and—at times—so did language. But throughout it all was harmony of effort in striving toward the one goal,—increased usefulness of the Society to its members, and of the Society to its country.

The meeting was largely in the hands of two very forceful and businesslike individuals—George Herrick Duggan, the retiring president, and John Stoughton Dennis, the president-elect. Both are men of action, accustomed to swing big things and to push them along with dispatch. Immediately after the meeting had been called to order at 10:20 a.m. Tuesday, January 23rd, Mr. Duggan assigned time for discussion of society affairs, and expressed a desire to complete the business on Wednesday if at all practicable.

"Let's get through with this in two days instead of three," he said. And they did. For the first time in the Society's history the meeting was concluded in two days. Yet nothing was left undone—the entire program was carried through and much that was not on the program—and probably more beneficial discussion was evolved than at many other annual meetings.

In pushing things through in this way Mr. Duggan had a very able assistant in the president-elect, Colonel Dennis. From the moment he first spoke, the members knew that Col. Dennis intended to put some of his western "pep" into the meeting. It was generally prophesied that 1917 is going to be a year of real activity in society circles.

Tuesday Morning Session.—One hundred members were present when Mr. Duggan called the meeting to order, but this number was about doubled later on. Prof. C. H. McLeod, the secretary, read the minutes of the last annual meeting. Adopted.

President announced changes in program, as noted above.

President appointed the auditors of the Society, Messrs. Riddell, Stead, Graham and Hutchison, chartered accountants, as scrutineers, thus following the new precedent established last year.

After quite a little discussion as to the order to be followed in the newly arranged two-day program, this was settled satisfactorily to all parties concerned, and the reports of council and council's committees were received. Discussion on these was adjourned till the afternoon session, to be merged with the discussion on the progress report of the Committee on Society Affairs.

R. A. Ross, chairman of the Finance Committee, presented the following report:—

"Supplementing the annual statement of the auditors, the Finance Committee submits a table (see next page) showing receipts and expenditures for the last ten years, upon which they have the following comments to make:—

"1st. It will be noticed that the total receipts for 1916 are about $1,000.00 in excess of the next highest year, namely, 1912.

The 1917 Council

President
Col. John Stoughton Dennis

Vice-Presidents
A. St. Laurent, Ottawa
T. H. White, Vancouver
J. M. R. Fairbairn, Montreal
Col. C. N. Monsarrat, Montreal

Past Presidents
M. J. Butler, C.M.G., Montreal
F. C. Gamble, Victoria
G. H. Duggan, Montreal

Treasurer
E. Marceau, Montreal

Secretary
Prof. C. H. McLeod, Montreal

Councillors

J. R. W. Ambrose, Toronto	E. D. Lafleur, Ottawa
C. B. Brown, Moncton	D. O. Lewis, Victoria
S. P. Brown, Montreal	Horace Longley, St. John
W. G. Chace, Winnipeg	G. A. McCarthy, Toronto
A. R. Decary, Quebec	William Pearce, Calgary
A. A. Dion, Ottawa	D. A. Ross, Winnipeg
H. Donkin, Halifax	R. A. Ross, Montreal
A. E. Doucet, Quebec	H. R. Safford, Montreal
T. A. J. Forrester, Quebec	Julian C. Smith, Montreal
Walter J. Francis, Montreal	A. Surveyer, Montreal.
J. H. Kennedy, Vancouver.	J. L. Weller, St. Catharines
N. J. Ker, Vancouver	James White, Ottawa

"2nd. That the expenditure for 1916 corresponds very closely with that for 1912, in spite of the fact that our franking privileges have been cancelled, postage rates increased.

"3rd. One essential difference between those comparable years, 1912 and 1916, is that during the latter year the arrear collections were something over twice those of 1912. On the other hand, the entrance fees in 1912 are very much larger than 1916.

"4th. The moral of the above is that every effort will have to be made to increase the membership, which will assist doubly by increasing current as well as entrance fees."

Mr. Ross said that there should not be too much rejoicing at the credit balance shown in this year's report as it was due entirely to the arrears collected, and that after the "clean-up" of this item that had taken place in 1915 and 1916, the Society is hardly likely to be able to collect nearly so much on this item again.

Walter J. Francis said that Mr. Ross had brought in a splendid report despite the Finance Committee's rather pessimistic report of last year, and despite the fact that no dues are charged to the 687 members who are in active military service.

The reports of branches were read and accepted. These are summarized on other pages of this issue. It was remarked that there was no report from the British Columbia Division and some disappointment was expressed at the seeming lack of interest shown by that Division after the enthusiasm with which it was launched last year.

Prof. H. E. T. Haultain suggested that the rebates to branches be reduced and stated that the Toronto members would be satisfied with smaller rebates. The new chairman of the Toronto Branch, E. W. Oliver, tactfully refused to commit the branch to any suggestion along this line, however, and the matter was dropped.

At 11:30 a.m. the report of the Conservation Committee was received, and the remainder of the session was occupied by its discussion. James White, chairman of the committee, and deputy head of the Commission of Conservation of Canada, read the report, abstract of which was printed in *The Canadian Engineer*, page 59, January 18th issue. He also read a letter from W. H. Breithaupt, of Kitchener, Ont., referring to the town-planning projects now being undertaken by Kitchener, Waterloo, Brantford, Ottawa, etc.

Mr. White referred to an address recently given by Lionel Curtis, in which Mr. Curtis professed belief that Canada would be flooded with British labor after the war, and that it would be a grave matter if these immigrants were to be allowed to mass in the cities. In South Africa, after the Boer war, the country could not absorb the flood of immigration, and a large part of the disfavor in which South Africa was for some time held in Great Britain, was the result of that fact.

Mr. White suggested that each community be requested, or even required, to absorb at least the number of men it sent to the war, restoring them to their old positions or equal ones.

These remarks brought on a brief discussion of after-the-war problems, and M. J. Butler, C.M.G., enquired whether the Honorary Advisory Council for Scientific and Industrial Research (hereafter called the "Research Council" for brevity), recently appointed by the Department of Trade and Commerce, intended to help the manufacturers on specific problems. In other words, would they get into such position that manufacturers could turn over definite, practical problems to them for solution?

R. A. Ross, who is a member of the Research Council, explained in a very clear-cut and convincing manner just what the Research Council is doing. He said that there is a fund of information buried in the government fyles and that they intend to disinter it and correlate it to the point of real usefulness. A census is also being taken to reveal where and what the raw material problems are, and in this the manufacturers must help the Research Council if they wished to be helped later on by the Research Council.

Adverting to the discussion on the Conservation Committee's report, Walter J. Francis intimated that the committee's work overlapped the work of the Commission of Conservation, and therefore was not conservation at all.

RECEIPTS AND EXPENDITURES—CANADIAN SOCIETY OF CIVIL ENGINEERS.

Receipts (in Dollars).

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.
Arrears collected	2,023	2,390	2,023	4,031	2,092	2,887	1,994	3,298	6,733	6,512
Current fees	6,102	7,089	7,963	9,491	11,893	13,897	15,037	15,616	12,438	13,176
Advance fees	144	203	376	134	288	158	186	270	139	153
Entrance fees	1,450	2,010	2,190	2,124	2,779	4,077	4,169	2,895	2,233	2,485
Total	9,719	11,692	12,552	15,780	17,052	21,019	21,386	22,079	21,543	22,326
Interest received	86	99	211	252	187	1,393	894	315	450	429
Miscellaneous receipts	623	630	188	79	174	341	225	172	87	972
Total	10,428	12,421	12,951	16,111	17,413	22,753	22,505	22,566	22,080	23,727

Expenditures (in Dollars).

Interest paid	—	—	—	—	—	854	1,695	1,201	1,200	1,200
Printing and stationery	3,608	4,055	4,902	6,268	3,757	6,865	6,416	10,551	5,970	6,691
Salaries and wages	3,485	4,633	4,042	3,845	4,714	5,195	4,906	5,652	4,909	5,180
Taxes and water	224	226	244	244	247	848	1,466	1,448	1,280	1,300
General expense	2,192	2,515	2,760	2,670	4,198	4,307	5,257	4,812	4,151	3,260
Branch societies	—	544	374	648	1,118	2,810	2,121	2,296	2,266	2,454
Total	9,509	11,973	12,322	13,675	14,034	20,879	21,861	25,960	19,776	20,085
Excess receipts	919	448	629	2,436	3,378	1,874	646	—	2,304	3,642
Excess expenditures	—	—	—	—	—	—	—	3,394	—	—

He suggested that the committee be discontinued, and, as previously stated by Mr. White, this was the view of some of the committee's own members though not his own view necessarily.

J. B. Challies urged that the committee devote its attention to straightening out "kinks" and overlapping between existing bodies, commissions, government departments, etc., such as in the correlation of reports, the division of territories to be covered and duties to be performed, etc.

Mr. White said that the Commission of Conservation is poorly named. It should be the Commission for the Economic Development of Canada, as that is its real work.

The meeting decided to continue the committee, with Mr. White as chairman, but to reduce the number of its members in order to get a more efficient working body, twenty-three being considered too many.

The session then adjourned till 3 p.m.

Tuesday Afternoon Session.—The presidential address, an abstract of which is presented on page 95 of this issue, was read by Mr. Duggan.

Prof. H. E. T. Haultain read the progress report of the Committee on Society Affairs, both he and Mr. Oliver, the secretary of the committee, outlining the organization of the committee, the letters sent out by them to the membership, and the consensus of opinions shown by such replies as were received.

Some discussion arose as to whether adoption of the committee's progress report would bind the Society to the definite carrying out of all the committee's recommendations, and whether such adoption would be tantamount to instructing the council to put the machinery in motion to carry out those recommendations.

The general opinion was against giving definite and final instructions on so many matters of grave import to the Society upon such short notice and with such short time for thorough discussion, and even Prof. Haultain and Mr. Oliver urged that this be not done, as there were many different ways in which some of the recommendations could be made effective, and the committee wanted further time to investigate so as to be able to make a more complete report at the next annual meeting. All the committee members desired to know was whether they are working along the right lines and whether the meeting approved of the directions in which they are turning their efforts. If so, the details could be worked out and submitted later.

The meeting expressed approval of all the tentative recommendations excepting one which suggested a change in the Society's name.

The committee had recommended "Canadian Institution of Civil Engineers" instead of "Canadian Society of Civil Engineers." It was thought that the word "Institution" would help in getting government grants, and also would follow the British style of name.

Prof. Haultain said that the committee had not been unanimous in making this recommendation. He, himself, for instance, preferred a more radical change and advocated dropping the word "civil" so as to get more mining, mechanical, chemical, electrical and other engineers into the Society.

A. A. Dion said that the word "civil" is being used by the Society in its antiquated sense of "non-military," and that the Society embraces now and wants to embrace all classes of engineers in Canada. But not all dictionaries give that definition to "civil engineers," said Mr. Dion. Colleges and universities to-day have courses in civil, electrical, mechanical engineering, etc., and the word "civil" there has a much narrower meaning than that in which the Society is now using it. And most people take the narrower meaning of the word. In other countries there are societies of civil engineers, societies of mechanical engineers, societies of electrical engineers, etc., and to the people of those countries "civil" means civil in its narrower sense.

So, said Mr. Dion, many engineers in Canada who are not interested in steel and concrete, sewers and roads, dams and bridges, and such work, are holding aloof from the Society. The question is whether to encourage the formation of other societies or to merge all in one. He was in favor of the latter.

Prof. Haultain said his interest in the Canadian Society of Civil Engineers is in the usefulness it can show to the mining engineers. There is now a Canadian Min-

"For Valor"

Following is a list of the decorations that have been conferred upon Canadian Society of Civil Engineers members so far as information has reached the secretary. Members will confer a favor by reporting any omissions:—

Name.	Rank.	Decoration.
	Members	
Hesketh, J. A.	Lt.-Col.	D.S.O.
Macphail, J. A.	Lt.-Col.	D.S.O.
Meurling, H. F. M.	Captain	Military Cross
Mitchell, C. H.	First Staff Officer 2nd Brit. Army	Officer's Cross of Legion of Honor
Ramsay, C. W. P.	Lt.-Col.	C.M.G.
Wilkin, F. A.	Major	D.S.O.
	Associate Members	
Bodwell, H. L.	Major	D.S.O.
Cosgrove, John R.	Lieut.	Military Cross
DeLancey, J. A.	Captain	Military Cross
Hertzberg, C. S. L.	Lieut.	Military Cross
Hertzberg, H. F. H.	Captain	Military Cross
Irving, T. C., Jr.	Major	D.S.O.
Klinger, L. W.	Lieut.	Military Cross
Leckie, R. G. E.	Brig.-Gen.	C.M.G.
LeCointe, P. L. P.	Corp.	Croix de Guerre
MacLeod, Geo. W.	Major	D.S.O.
Mulock, R. H.	Flight Sub.-Lt.	D.S.O.
Perry, K. M.	Major	D.S.O.
	Juniors	
Anderson, G. F.	Lieut.	Military Cross
Ferris, C. B.	Sergt.	Croix de Guerre
Junkin, R. L.	Lieut.	Military Cross
Powell, R. W.	Lieut.	Military C. & Bar
Spencer, R. A.	Captain	Military Cross
Turner, G. R.	Lieut.	Military Cross
	Students	
Creasor, J. A.	Lieut.	Military Cross
Johnson, G. A.	Lieut.	Military Cross
Merston, W. C.	Lieut.	D.C.M. & M.C.
Urie, H. R.	Lieut.	Military Cross

ing Institute, but that body includes mining brokers, etc., and is not a professional body in the same sense as is the Canadian Society of Civil Engineers. It is a trade body, and in order to attain professional standing its engineering members should join the Canadian Society of Civil Engineers. But a group of men is at work now trying to remodel the Canadian Mining Institute into a professional body, and the Canadian Society should drop the word "civil" and get these miners in before they make their own institute self-sufficient and so be lost forever to the Canadian Society of Civil Engineers, which, under that title, would never be very attractive to many mining engineers.

Prof. Haultain urged a change of name to "The Canadian Institute of Engineers," and R. A. Ross agreed with him from the viewpoint of the electrical engineer.

George A. Mountain said that it was he who first suggested the change of "Society" to "Institution." But he had never suggested dropping the "civil," and he was in favor of retaining "civil" in the title if the society, or institution, never got a dollar of government money, and he would rather have the name as it is than change it to "institution" without the "civil."

George A. McCarthy suggested that the matter be sent on to the various branches for discussion, with a letter ballot of the membership to be taken afterwards by council. Col. Anderson moved that the matter be referred back to the committee to lay before the members as Mr. McCarthy suggested. Carried.

Discussion of report of council, adjourned from the morning session, was completed. Col. Dennis referred to the work some members have been doing in meeting national problems. He said that Mr. Tye's address, presented very recently before the Montreal members of the Society, is a most valuable contribution to one of the greatest problems confronting Canada to-day,—the transportation problem. Mr. Tye's paper has put the problem within reach of everyone. It was an exceptionally able paper, and the Society can strengthen its position by giving publicity to contributions of this kind. Another noteworthy effort by members of the Society was a memorandum on industrial preparedness of which he had been given an advance copy and which had not yet been made public. This was a purely voluntary effort by certain members of the Society to help in dealing with some of the greatest problems the Dominion ever had to confront, and it, too, should be published at once.

The meeting adopted the report of council and adjourned till 3 p.m., Wednesday, January 24th.

Tuesday Evening Entertainment.—At 7 p.m. an informal dinner was served in the University Club, complimentary to visiting members. No speeches were made. The only toast was to the King. At 8:50 o'clock the diners crossed the street to the Society's building, where a "smoker" was much enjoyed. Through the efforts of the entertainment committee, Messrs. Duchastel, Beaubien, Black, DeCew, Mattice, Tennant and Wilson, various vaudeville talent had been secured, and the members were entertained until a late hour.

Wednesday Morning Trip.—Special cars left the Windsor Hotel at 9 a.m. Wednesday, taking 125 members to the munitions plants of the Dominion Bridge Co., the Montreal Ammunition Co., and the Dominion Copper Products Co. All departments of these huge works were inspected by the visitors who were greatly interested in all the up-to-date methods for shell manufacture. Returning, the cars left Dominion, P.Q., at 12:20, arriving at the Windsor Hotel about 1 o'clock. The companies whose works were visited entertained the party at luncheon at the hotel. George A. Mountain moved a vote of thanks to the companies. Phelps Johnson replied, saying that he hoped they would be able to shut down on the munition work just as soon as possible. He hoped the war would soon come to a successful conclusion. After the war the Dominion Copper Products Co. would probably be continued to manufacture other copper products.

Wednesday Afternoon Session.—Reception of reports of committees was continued. J. C. Parker presented the report of the Committee on Roads and Pavements, and asked that Appendix II. (see page 65, January 18th issue of *The Canadian Engineer*), the specification for sand, gravel and crushed stone, be adopted; and that Appendix I., the list of pavements reported, and Appendix III., the tentative specification for asphaltic materials, be received but not adopted, pending further report upon them at the next annual meeting.

Prof. Brown enquired whether the specification for sand, gravel and crushed stone overlaps the standard specification for concrete and reinforced concrete now in use by the Society. Mr. Parker said that the only place in which the two specifications overlap is in the grading of the concrete sand. The concrete committee specified the sand to pass through ⅛-inch screen, while the roads committee specifies ¼-inch screen. The mortar tests were those adopted by the American Concrete Institute in their specifications for concrete roads and alleys.

Walter J. Francis urged that there be a conference of the two committees before adopting this specification, as it would be unfortunate if two standard specifications of the Society should conflict. At this point the secretary read a telegram from W. G. Chace, of Winnipeg, saying that clauses 3—1 and 3—2 of the sand specification would give coarse sands, wasteful of cement.

J. R. W. Ambrose asked if the specification follows the line of maximum density found by Mr. Davis, of the Toronto-Hamilton Highway Commission, in his experiments on this subject. Mr. Parker replied that this specification follows all United States specifications for sand for pavements. "Twenty-five per cent. passing 50-mesh sieve, and 5 per cent. passing 100-mesh sieve," is in all United States specifications, said Mr. Parker, the general feeling being that coarser sand would be desirable.

Mr. Parker urged that these specifications be adopted and used until something better is found. He said they are very open. A great variety of sands from very good to very bad will meet these requirements. There are a number of experiments being tried out in the United States, using fineness modulus, uniformity coefficient, etc., and it is desirable to wait and see how these work in practice. Meanwhile, there is a crying need for some guide for engineers in this country, and this specification is good enough to fill the bill for this year.

P. B. Motley asked that the adoption be deferred. Mr. Chace had made very extensive field and laboratory tests of sands. Had the committee considered those experiments? The Concrete and Reinforced Concrete Committee intend to study Chace's experiments to improve on their own specification. The sand specification now offered does not agree with that of the American Society for Testing Materials, or of the Canadian Society's Concrete Committee. It is not the standard specification of any United States scientific body.

J. A. Jamieson said it would be a decided mistake to adopt any hard and fast specification for sand for any class of concrete work, as in some parts of Canada it is

very difficult to get sand to meet these specifications without going to greater expense than would be required by the use of more cement to fill the voids.

Mr. Parker said the committee had borne that fact in mind and had stated in their report that this specification would not be applicable to certain districts. This specification is merely a guide.

Prof. Brown said that concrete pavements may require quite a different specification than other concretes, and that a concrete that would be suitable in a street might not at all be suitable in a building. Mr. Jamieson replied that concrete is concrete, whatever its use, and varies only in the sizes and proportions of the aggregates.

Geo. A. Mountain approved of the specification as one of the best that had ever been presented to the Society and said it should not be referred back, but should be adopted and recommended to all members for general use. Prof. Haultain saw no objection to its adoption, provided that it would be made quite clear that it is for roads and pavements only, so that nobody would confuse it with specifications for similar materials for other classes of work.

Mr. Parker stated that the value of grading sand from 1/8-inch could be determined only by much further experimental work. The work has now been done from 1/4-inch, and the additional experiments cannot be performed in the period of the next year. The specification is intended to evoke discussion among the members and is not meant to be used unqualifiedly. No doubt it will not be a satisfactory specification ten years from now, but it can be changed any year.

J. R. W. Ambrose said that it was such a satisfaction to get so definite a specification and report from any committee of this Society that he thought it would be a shame to refer it back. The committee had made exhaustive tests and experiments and the Society should adopt the specification.

The president suggested that the specification be labeled "Tentative," but Mr. Mountain said every specification is tentative until something better is produced.

M. J. Butler, C.M.G., called attention to the use of the word "graded," which, he said, is a dangerous word in any specification if used in such a way that some may interpret it as requiring an artificial grading. It is an ambiguous word that implies that something must be done with sieves.

Mr. Parker moved that the specification be adopted and the committee continued. Carried. Moved that the remainder of the report (Appendices I. and III.) be received. Carried.

Electro-Technical Report.—Prof. Herdt moved that the report of the International Electro-Technical Commission Committee (summarized on page 59, January 18th issue, *The Canadian Engineer*) be adopted and the committee continued. Carried.

Steel Bridge Specifications.—P. B. Motley presented the report of the committee on steel bridge specifications and moved that the committee be continued for the year, but that it be reconstituted as outlined in its report (see page 59, January 18th issue, *The Canadian Engineer*), all members to be named by March 1st, the council then naming a representative for any branch that might have failed to do so by that date.

J. R. W. Ambrose expressed disappointment at the committee's report. He said this committee includes nine of the leading bridge engineers in this country and should have gotten out something better.

Geo. A. Mountain said there should soon be a standard Canadian Society specification for steel bridges. There are now three or four in use and there is no accord. The Canadian Pacific uses their own, the Grand Trunk Pacific and Canadian Northern use the Dominion Government's specification, while the Grand Trunk Railway uses the American Railway Engineering Association's specification. In some of them it is often difficult to tell whether impact is included or not, etc.

C. M. Goodrich said that a highway bridge specification is more difficult than a railway bridge specification, and intimated that the members should have patience with the committee.

Geo. A. McCarthy and Walter J. Francis both approved of the committee's work. Mr. Francis said that very fruitful discussion had been brought out at the Montreal meeting, at which the draft specification had been presented.

Mr. Motley said that a highway bridge specification is four times the size of an ordinary railroad bridge specification and could not be disposed of in one year by a committee like the present one.

F. P. Shearwood referred to a question on which the committee members had differed. The question is whether practically to design the bridge in the specification, or to leave as much latitude as possible to the engineer. He requested the annual meeting to instruct the committee to prepare a specification that would ensure safe bridges and economy of material, but that would not restrict the engineer unduly in his design. The consensus of opinion was that the meeting should not interfere in this manner in a subject that should be settled by the committee.

Geo. A. Mountain said the Dominion Government, the Ontario Railway and Municipal Board and the Alberta Government all have separate and varying specifications, and that undoubtedly other provinces will follow. He hoped that this movement toward a multiplicity of specifications would very soon be checked by the Canadian Society's issue of a standard specification, and that he would recommend its adoption by the Dominion Railway Board just as soon as it is issued.

J. S. Dennis moved that the committee be continued and be requested to submit a draft specification to the next annual meeting, and that meanwhile their existing draft be mailed to all branches for discussion. Carried.

The question of personnel of the committee arose again. M. J. Butler, C.M.G., said that the reason for naming the committee in its present form is obvious. If this committee, constituted as it is, brings in an unanimous report, its specification will at once become standard with the C.P.R., the Grand Trunk, the Railway Board and all other interests represented. He would be sorry to see one name off. J. S. Dennis said, "Absolutely so." Geo. A. Mountain asserted that no better committee could be gotten together than these nine men.

P. B. Motley replied that the committee is not representative of the branches. In each branch, if there is not a bridge engineer, there surely is at least a near bridge engineer, and the provincial officials can be consulted by that representative. Montreal is the centre, and the main work of the committee should be done there, he thought, but not one man should be left on the committee who had ceased to be active in its work.

J. S. Dennis concurred in the idea of provincial representation so as to get all the provinces interested in one specification. Each province now decides upon

its own bridges. The provincial representatives on the committee could add the suggestions of the local branches regarding highway bridges. A reconstituted committee that would take in those men would bring in something acceptable to everyone,—to provincial bodies as well as national. Leave the present committee stand but add a representative for each branch.

Geo. A. Mountain: "Too large for effective work."

J. S. Dennis said Alberta has a good specification for highway bridges that had been prepared when he was chief engineer for the Northwest Territories. When Alberta had been created, the provincial minister adopted the specification. Col. Dennis had asked various bridge engineers to prepare a short specification. These were studied and assembled by the Public Works Department, and the result—not any one man's work but an assemblage of the best suggestions from everyone—had been passed on to Mr. Cooper, one of the best-known bridge experts in the United States, and thus was secured an excellent specification. The men in the western provinces know how this specification came about and their opinions should be obtained and see how they fit in.

Walter J. Francis announced that the Province of Alberta had last week adopted a new specification based largely upon the work of the Society's committee. Mr. Butler: "Well, that is news, of course, if it happened only last week."

Moved that the committee be continued just as at present, but with authority to add to its numbers the representatives of the branches. Carried.

Educational Requirements.—Prof. H. M. Mackay moved the adoption of the report of the Examining Board and Committee on Educational Requirements. Carried.

Sewage Disposal and Sanitation.—A. Surveyer, chairman of the Committee on Sewage Disposal and Sanitation, presented the following report:—

"It was decided last year that sub-committees of this committee should be formed in each province in order to approach the different boards of health in an effort to induce them to adopt some of the suggestions made by your committee in 1915 and approved by the annual meeting.

"With this end in view Messrs. Andrew F. Macallum, A. J. McPherson, W. Muir Edwards and C. H. Rust were appointed chairmen of the sub-committees for Ontario, Saskatchewan, Alberta and British Columbia, respectively, the Quebec sub-committee consisting of Sir John Kennedy, Messrs. Théo. J. Lafrènière, R. S. Lea, W. S. Lea, J. O. Meadows and Arthur Surveyer.

"On the 23rd of June a delegation from this sub-committee met by apointment the Superior Board of Health of the province of Quebec and urged upon the board the advisability of amending the Quebec Public Health Act so as to embody the following suggestions:—

"That at least two engineers should be members of the Quebec Superior Board of Health.

"That all reports or plans submitted to the board should be signed by an engineer qualified to practice in the province of Quebec.

"That rules should be drafted to cover the preparation and submission of projects.

"That no by-law providing for the raising of money for the construction, alteration or extension of any works coming under the jurisdiction of the board of health should be submitted to the votes of the electors without first being approved by the board of health.

"That extensions or alterations to existing works should be submitted to the board of health for approval, just the same as new works.

"Our delegation was well received by the board of health and consideration was promised. Since that date the term of office of three of the members has expired. Mr. R. S. Lea, member of the society, was reappointed on the board, but, notwithstanding the fact that we urged by letter upon the president of the Superior Board of Health the advisability of filling one of the two other vacancies by an engineer, two doctors were appointed. The personnel of the board remains as heretofore, viz., eight doctors, one dentist and one civil engineer. It is fair to say, however, that the appointments are made by the Governor-in-Council and not directly by the Superior Board of Health.

"At the last session of the Quebec legislature the Quebec Public Health Act was amended, but none of the amendments were in the line of our suggestions except one, which followed to some extent our last recommendation. It is the writer's belief, however, that the members of the board of health had already decided that this amendment was desirable before we approched them.

"Since our visit we understand that the board of health has taken up the study of regulations to cover the preparation and submission of projects. We cannot, however, claim very great success, as our most important recommendations have not been acted upon. It is possible, however, that although loath to take the initiative, the Superior Board of Health might adopt a neutral attitude towards some of these recommendations if the Society were to bring them up to legislature as amendments to the Public Health Act. The question which this meeting has to decide is whether or not the Society, following up its last year's manifestations of interest in public affairs, should move a step further ahead and offer amendments to the laws of the country when it feels that these amendments are for the general welfare of the community."

It was moved that the report of this committee be received and that the council be instructed to appoint a Committee on Legislation to deal with this question and with other similar questions. Carried.

Concrete and Reinforced Concrete.—Walter J. Francis, chairman of the Committee on Concrete and Reinforced Concrete, said that the committee had done a good deal of work this year, but had nothing definite to report. They had received very exhaustive suggestions from the Toronto Branch. What they had been hoping for was that some authoritative body in the United States would issue a specification on concrete and reinforced concrete, but none had been forthcoming. There are some things in the specification which they would like to remodel when the time comes. The committee would like to have suggestions filed during the year and they would be considered for the next report.

Mr. Francis was asked whether the Joint Committee on Concrete of the various American societies had not recently brought down a specification. He said they had made a report, but had not issued a specification, and that they had evidently been stuck on the same matters as had the committee of the Canadian Society.

J. R. W. Ambrose enquired whether the Canadian Society has to wait for another body to issue specifications. Why were not the Toronto branch suggestions laid before the annual meeting as a basis for criticism?

Mr. Francis explained that he had received one or two complete sets of specifications from the Toronto

branch, but that the committee would like to keep them under advisement to use as suggestions for the coming year.

Mr. Ambrose called attention to the fact that the Toronto branch suggestions were already one year old and that there should have been plenty of time for their consideration and discussion.

"The Canadian Society has not waited upon other bodies in this matter," said Mr. Francis. "We took the lead and issued the first definite specification ever published for concrete and reinforced concrete. There have been reports by American societies, but not in definite specification form." Mr. Francis said that some of the clauses of the Toronto specification were the same as the Society's standard specification with the exception of phraseology.

"The committee is to be congratulated upon its former activity," said Mr. Ambrose, "but the suggestions made in the past year should have been laid before this meeting." Moved that the committee's report be accepted and the committee continued. Carried.

General Clauses.—No member of this committee was present and no report was received. Col. Anderson moved that the committee be continued. Mr. Oliver objected to the continuation of a committee that did no work. Mr. Butler said he knew that the chairman, Mr. Holgate, had done a very great deal of work upon this matter, but that on account of illness in his family he had been unable to be present to present a report. Mr. Ambrose complained that the Toronto branch had forwarded a very exhaustive report upon this subject a year ago, but that no acknowledgment of it had ever been received from Mr. Holgate.

Mr. Oliver explained that the Toronto branch had organized several committees to work along with those at headquarters, with the idea of stirring up enthusiasm. These committees had met with so little encouragement that at the last meeting of the Toronto executive the practice had been questioned, but he felt that it was a very good one and should be encouraged.

Mr. Oliver proposed an amendment to Col. Anderson's motion, that the committee be reorganized with a different personnel. Lost on division. Col. Anderson's motion was then put to the meeting and carried.

Boiler Specifications.—The secretary read a report by L. M. Arkley, chairman of the Committee on Uniform Boiler Specifications. At a meeting held in Montreal, August 18th, 1916, at which members from Amherst, N.S., St. John's, N.B., and Toronto, were present, it was decided that the six Toronto members of the committee form a sub-committee to compare the existing rules for the construction and inspection of steam boilers adopted by Ontario and the other Provinces of Canada, with the Boiler Code of the A.S.M.E.; and to formulate a specification based on those in use in Canada at the present time, with the addition of such specification of materials and other clauses of the A.S.M.E. code which are considered desirable to supplement the present rules without conflicting with them. The sub-committee hopes to be in a position to make a definite recommendation at the next annual meeting. Report adopted and committee continued.

Cement Specifications.—J. A. Jamieson said he had been surprised to hear that the committee on cement specifications had been discharged after its report had been handed in last year. He had differed from some of the other members of the committee in some essential particulars, and had signed the specification for use during the year only, hoping that by another year the committee would be able to evolve a better one. In some points the present specification handicaps the manufacturers, which is not desirable. He moved that a new committee be appointed to reconsider the specifications.

Prof. Brown said that the American Society of Civil Engineers have changed their specification during the past year, doing away with tests of neat cement and depending entirely on cement mortar tests. The British Institution differs in many ways in their specification from both the American and Canadian bodies. The Canadian Society was uniform with the American Society in its requirements, but this is not so now. A new committee would be desirable. Mr. Jamieson's motion carried.

New Business.—Prof. C. H. McLeod read the following letter from J. B. Challies, secretary of the Research Council:—

"The Advisory Research Council are preparing to secure a confidential inventory of Canada's facilities for scientific and industrial research, in order that they may be able to consider ways and means for effecting:—

"(*a*) The co-ordination and co-operation of all research agencies.

"(*b*) The extension and expansion of existing research.

"(*c*) The mobilization of the scientific man-power available for research.

"To this end, suitable questionnaires have been prepared to be sent out to the following groups:—

"No. 1—Universities, colleges and technical institutions.

"No. 2—Government departments (Dominion and provincial).

"No. 3—Managers and directors of Canadian industries.

"No. 4—Members of scientific, professional and technical societies.

"Little difficulty is anticipated in securing suitable and prompt replies from groups 1, 2 and 4, but there may be some trouble in obtaining satisfactory results from group 3,—the manufacturers and industries of the Dominion.

The Council are aware that the success of the industrial inventory of the United States, taken a few months ago, was very largely due to the fact that the national engineering societies of the United States undertook, through their own organizations, to have the forms presented to the manufacturers throughout the country properly filled in and promptly returned to the director of the industrial inventory. The Council, therefore, feel that, if they had the advantage of the assistance of the Canadian Society of Civil Engineers in connection with their questionnaires to manufacturers and industries, satisfactory results would be achieved.

"Could the Advisory Research Council obtain the co-operation of the Canadian Society of Civil Engineers in this important matter? If so, it would be of great service to the country and would be very gratefully appreciated."

R. A. Ross, discussing the above letter, inferred that it had been read to the members in meeting instead of being dealt with by the Society's council in order that the members would be acquainted with the activities of the Research Council and know the opportunities for rendering national service that are now offered. Out of

about 30,000 forms sent out by the United States Naval Board, over 25,000 had been returned as a result of the co-operation of the engineering societies.

The Canadian Society of Civil Engineers extends to every town in Canada, said Mr. Ross. It includes municipal engineers and others who are familiar with everything in their own bailiwick. The outlying districts would be largely covered through the mining societies. The Canadian Mining Institute, the Society of Chemical Industry, the Canadian Manufacturers' Association, and three or four other groups are being asked to help in the same way. Possibly a joint committee could be formed of all of these societies to direct the efforts of their members. The manufacturers' association would supply a list of all of the manufacturers. The Canadian Society of Civil Engineers is the most powerfully organized technical society in Canada—with over three thousand members from coast to coast—and they will be able to render dominate assistance in the inventory.

J. S. Dennis said that in connection with research work of this character he wished to call attention to the memorandum on national industrial development in Canada that had been prepared by Sir Charles Ross, Prof. C. H. McLeod, R. A. Ross, H. R. Safford and Walter J. Francis, the last four being well-known members of the society, and presented to the government of Canada. He said that the Society is to be congratulated upon having in its ranks men who have been able to deal with such important questions so satisfactorily. He hoped their memorandum would be published.

The Society should assist in industrial mobilization, continued Col. Dennis. The C.P.R. is assisting where possible. It has undertaken to make an exhaustive survey of the Dominion, collating from all government reports the information regarding the location and extent of our natural resources, having a corps of experts report on them, and also paying especial attention to statistics regarding labor shortages in all lines of endeavor, particularly agricultural.

Ontario and the East are being handled from Montreal in this survey, while Calgary is the headquarters for the West. Seven or eight thousand correspondents have been in communication, and a series of questions have been asked somewhat along the lines now suggested by the newly appointed Research Council. Col. Dennis said he was surprised at some of the results obtained. The lists of manufacturers had been secured from their association, the names of the mines from their published reports and from the provincial governments, and the lists of agriculturists through their societies and from the departments of agriculture. The returns show a marked labor shortage in agricultural and some other lines, and there is no doubt but that Canada will be able to locate many from the front if these conditions continue until after the war. There are many sides to the matter and we would fall short of solving the gigantic problem if attention is paid only to industrial development.

Col. Dennis referred briefly to his own activities in Canadian research work and in interesting the United States so as to obtain capital for development of our resources. He is making a series of addresses in Canada upon these topics, and is also giving ten addresses in the United States under the title of "Your Neighbors on the North," outlining Canada's resources and opportunities. He moved that the invitation given by the Research Council should be accepted, saying that its message should carry home to every member of the Society. Carried unanimously.

W. F. Tye moved that the memorandum by Messrs. McLeod, Francis, Ross and Safford be printed. "The efforts of these men," said Mr. Tye, "were largely responsible for the appointment by the government of two members of this Society as members of the Research Council." Mr. Ross here called attention to the fact that a third member of the Society, Mr. Challies, is now secretary of the Research Council.

J. G. Legrand:—"At this crucial moment, when it is a question of life or death, we must wake up. The Canadian Society of Civil Engineers especially must help the great cause in supporting the resolution made by important groups of men and associations to obtain a national government composed of the best men the country can produce, men representing all classes regardless of political opinions, which in this terrible crisis should have been eliminated the day after war was declared, thus saving thousands of lives and millions of dollars. During this meeting a committee should be appointed to prepare a resolution to that effect, worded in such a way as to be unanimously adopted by all the members present.

"I read in *The Canadian Engineer* of January 4th an article entitled 'Engineers Will Offer Services.' In this article it was stated that Mr. O'Hara, deputy minister of trade and commerce, intimated that the government does not understand clearly just how engineers might like to help, and suggested to Mr. Maclachlan, secretary of the Canadian Electrical Association, that the engineers should get together and present some definite plan of action to the government. Mr. Maclachlan might have answered Mr. O'Hara that it is not for an officer to ask a soldier what he is willing to do, but to command, and he will find that in the case of engineers they have been trained to do almost anything, and that some of them can give lessons on organization and prompt execution.

"The Society should select a member of wide experience who could be consulted by the national government on engineering matters and any big problem could thus be handed to him and he in turn could command the assistance of such members of the Society to enable him to solve the problem efficiently and promptly."

Next Meeting Place.—An invitation was presented by Col. Dennis on behalf of the Calgary branch, to hold the 1918 annual meeting at Calgary. This was accompanied by letters of endorsement from the city council, the board of trade and other Calgary institutions, and also from the society's branches at Winnipeg, Regina, Edmonton, Vancouver and Victoria.

The proposal was also endorsed in person by A. S. Dawson, chairman of the Calgary branch, who said:—

"It is most desirable to broaden out the operations of the parent society, which have been too provincial in their scope. There should be closer work and closer co-operation between the parent society and the various branches. The latter should be considered and looked upon as actual component parts of the parent society, and not mere affiliated organizations.

"The west has different types of engineering works than may be seen in the east; but they are none the less interesting and none the less important. The time is coming when it will be a case of the mobilization of the natural resources of the country, instead of men fit for military service. It behoves each of us to do our part in furthering the interests of the society by losing sight of personal interests and striving to elevate the profession as a whole; and in so doing to make a printed code of ethics unnecessary.

"I desire to endorse the invitation just presented to hold the 1918 meeting of this society at Calgary. Come west and get the optimism which prevails on those great broad prairies!"

In the letter of invitation from the Calgary branch, which was read by Col. Dennis, Sam G. Porter, the secretary-treasurer of the branch, said:—

"The western members of the society feel that it is only fair that the annual meetings of the society be held in the west occasionally in order that they may have the privilege of attending a convention held nearer their own homes. Up to the present time only one annual meeting has been held in the west,—the one at Winnipeg in 1911. We believe that the eastern members will recognize the justice of our claim and support our invitation."

Col. Dennis said that the Manitoba branch had passed a resolution supporting the Calgary branch in the latter's invitation, that Edmonton is in hearty accord with the proposal, and that Regina thinks it would be of great benefit to the engineers in the west to have an opportunity to attend an annual meeting. He referred to three great engineering features that the eastern members would see near Calgary—the Connaught Tunnel, the Bassano Dam and a reinforced concrete aqueduct, two miles long, for conveying water for irrigation purposes, which is the only one of its character on this continent.

W. F. Tye said that last year an endeavor was made to hold a summer convention in Vancouver and Victoria, but not very many eastern members signified their ability to go that far. He suggested referring the matter to council.

Col. Dennis said it is not a summer convention that is wanted. The western members want the business of the society to be carried on in the west for once. They would like a summer convention if they could not get the annual meeting, but would prefer the cow to the calf.

Mr. Tye then recommended the acceptance of the invitation. The branches should be satisfied in every way possible. The meetings could be held in different places. Montreal had gotten the reputation in the west of "hogging it." (Cries from western members, "No, no.")

Several members objected to holding the meeting in the west during the war, pointing out that the majority of members are in the east and the trip would involve great expense for these times, also referring to the expense of moving the society's statistical and business plant to the west for the purposes of the meeting, and to legal opinions, which state that annual meetings should always be held in the city in which the headquarters of any chartered society or corporation are located. A suggestion was made that a formal meeting of a legal quorum be called in Montreal early in January and adjourned to Calgary for a date later in the month.

"We are going to have these children in the west running after strange gods if we don't do something to bind them to us," said Col. Dennis. Mr. Uniacke moved that the matter be left in the hands of the council with a recommendation from the annual meeting that the meeting be held in Calgary if it be found possible and practicable to do so. Seconded by Mr. Tye and carried on division.

Report of Scrutineers.—The society's auditors reported that 420 ballot papers had been returned from members in good standing. Seventy-two had been returned by members in arrears, but the results of the election would in no case have been altered by counting these additional votes. J. S. Dennis, Montreal, was elected president (by acclamation); J. M. R. Fairbairn and Col. C. N. Monsarrat, both of Montreal, vice-presidents; and as councillors for three years, Messrs. A. R. Decary, Quebec; James White, Ottawa; Geo. A. McCarthy, Toronto; R. A. Ross, Montreal; Julian C. Smith, Montreal; J. H. Kennedy, Vancouver; William Pearce, Calgary; and Horace Longley, St. John, N.B.

The retiring president thanked the members of council, officers of sections and members of committees for their co-operation during the past year, and then introduced the new president, Col. Dennis, who took the chair.

President-Elect Takes Chair.—Col. Dennis said he naturally appreciates the honor, as no man could have greater satisfaction than to be selected by his fellows as the head of their organization, whatever it might be. This was only the second occasion on which he had ever attended an annual meeting of the society. It was true that he had been vice-president at one time, but he had never taken much part in the society's or its branches' affairs, and there were some doubts in his mind as to why he had been selected. He had not indicated any special interest in the society. One friend had told him that the society recognized the merits of western roughness, and that Dennis was the roughest of the roughnecks that they could find!

Amid laughter Col. Dennis continued that his headquarters are now in Montreal. His friends said that after forty-four years in the west it was time he came home to die, but he proposed to do some very vigorous kicking yet. Naturally, his friends, associations and interests are all in the west, but during his year of office he hopes to really do something for the society. The opportunity is great, as the Canadian Society of Civil Engineers is known throughout Canada as an organization not devoted entirely to professional interests or to individual or society advancement, but as one that is intimately concerned in improving Canada as a whole, and composed of men who will be outstanding in helping to solve the big problems confronting Canada.

Col. Dennis referred to the heart-breaking work in the west that has built up the reputation of the engineering profession in that great territory. In this work the society has a proud record, which he trusts can still be improved during the coming year. But the first work is to win the war. The Department of Natural Resources of the C.P.R., of which he was the head until last November 1st, had sent over four hundred men to the front. He was glad to see that the society had sent so many men, and hoped that an honor roll bearing the names of these men would be prepared and hung in the hall of the society's building.

Walter J. Francis moved that a cable be forwarded, bearing the greetings of the meeting, to Col. Chas. H. Mitchell and the other members of the society who are in the trenches. Carried.

Prof. McLeod read the report of the Gzowski Medal Committee, Phelps Johnson, chairman, recommending the award of the medal to Messrs. Henry Holgate, Julian C. Smith and R. M. Wilson for their series of three papers on the Cedars Rapids hydro-electric development. Approved.

The following nominations for Nominating Committee for officers and councillors for the year 1918 were made by the branches:—

H. M. Mackay, Montreal; J. S. O'Dwyer, Moncton; J. E. Gibault, Quebec; Geo. A. Mountain, Ottawa; J. R. W. Ambrose, Toronto; A. S. Dawson, Calgary; and H. W. E. Canavan, Victoria.

No other nominations being made by the meeting, the above gentlemen were declared elected by acclamation.

Moved by Col. Monsarrat and seconded by Geo. A. McCarthy, that an honor roll be prepared and exhibited in the building. Carried unanimously.

The meeting was adjourned about 6.45 p.m.

The new council met at 3 p.m. the following day and organized for the year. Prof. C. H. McLeod was re-elected secretary and E. Marceau, treasurer.

Registration at the Meeting.—Two hundred members registered at the annual meeting, of which about sixty-five were from outside of Montreal, as follows (in order of registration):—

W. J. Dick, Ottawa; W. H. Taylor, Winnipeg; J. G. Legrand, Winnipeg; M. Wolfe, Quebec; E. W. Oliver, Toronto; B. E. Norrish, Ottawa; R. F. Uniacke, Ottawa; G. G. Gale, Ottawa; P. H. Mitchell, Toronto; R. McColl, Halifax; D. W. McLachlan, Ottawa; A. L. Killaly, Peterboro'; C. B. Daubney, Ottawa; H. E. T. Haultain, Toronto; M. D. Nicholson, Goderich; E. A. James, Toronto; G. C. Parker, Toronto; L. P. Vezina, Chicoutimi; James White, Ottawa.

A. St. Laurent, Ottawa; A. A. Dion, Ottawa; W. S. Lawson, St. Johns, P.Q.; H. A. Paquette, Levis; C. M. Goodrich, Walkerville; J. G. Sullivan, Winnipeg; J. B. Challies, Ottawa; A. B. Lambe, Ottawa; G. A. McCarthy, Toronto; S. B. Clement, North Bay; Geo. A. Mountain, Ottawa; J. R. W. Ambrose, Toronto.

H. T. Hazen, Toronto; E. A. Stone, Kingston; A. Gray, Ottawa; S. Fortin, Ottawa; G. Stead, Chatham, N.B.; L. A. Desy, Ottawa; J. L. Busfield, Ottawa; J. W. Hayward, Toronto; W. D. Baillairge, Quebec; N. F. Ballantyne, Ottawa; G. H. Blanchet, Ottawa; E. V. Johnson, Ottawa.

R. F. Davy, Temiskaming, P.Q.; Wm. P. Anderson, Ottawa; H. B. Aylmer, Melbourne, P.Q.; George Kydd, Campbellford; T. U. Fairlie, Toronto; L. L. Ferguson, Frankford; W. F. M. Bryce, Ottawa; J. R. Bissett, Ottawa; A. F. Macallum, Ottawa; P. Charton, Paris, France; W. L. MacKenzie, Ottawa.

B. De Grand Mont, Quebec; Jos. R. Roy, Ottawa; J. F. Grenon, Chicoutimi; Victor F. Murray, Ottawa; H. L. Swan, Penticton, B.C.; A. S. Dawson, Calgary, Alta.; A. A. Colter, St. Mary's, N.B.; S. D. Fawcett, Ottawa; H. W. Melanson, Bathurst, N.B.; Hugh D. Lumsden, Orillia; E. A. Forward, Quebec.

256th RAILWAY CONSTRUCTION BATTALION.

On page 61 cx of this issue there will be found an advertisement of the 256th Railway Construction Battalion, Lieut.-Col. W. A. McConnell officer in command. This announcement is particularly called to the attention of engineers and engineering contractors. The battalion is being recruited for special railway work at the front and is anxious to enlist men who are familiar with construction work of all kinds. The physical standards which apply to regular infantry battalions do not hold when enlisting with the 256th, but the rate of pay is the same. The battalion will go to the front as a unit for special work. Another very interesting fact is that it will leave for overseas just as soon as it reaches strength.

AMERICAN ROAD BUILDERS' ASSOCIATION.

In arranging the programme for the seventh American Good Roads Congress to be held in Mechanics Building, Boston, Mass., February 5 to 9, under the auspices of the American Road Builders' Association, the committee in charge has selected a number of leading subjects and has decided to devote an entire session or a definite part of a session to the consideration of each topic. Each will be introduced in a formal paper prepared by a leading authority, and the subject will then be open for discussion by the delegates. Among the subjects to be treated at the various sessions are the following:—

Bituminous roads and pavements and treatments (sheet asphalt, bituminous macadam, bituminous concrete, etc., etc.); cement concrete roads and pavements; stone block roads and pavements; wood block roads and pavements; brick roads and pavements; traffic—its effect on design, construction and maintenance and its regulation; contractors' plant or equipment; earth, gravel, sand-clay and miscellaneous roads and pavements.

Among the papers which have been selected to be read during the convention are the following:—

"Policy and Programme of Government in Road Construction Under New Federal Aid Law," Logan Waller Page, director, United States Office of Public Roads and Rural Engineering.

"Highway Engineering Education," T. R. Agg, Professor of Highway Engineering, Iowa State College.

"Best Practice in Concrete Road Construction," H. E. Breed, First Deputy Commissioner, New York State Commission of Highways.

"Recent Practice in Granite Block Pavements," Wm. H. Connell, Chief, Bureau of Highways and Street Cleaning of Philadelphia, Pa.

"Recent Practice in Wood Block Pavements," Ellis R. Dutton, assistant city engineer of Minneapolis, Minn.

"Best Practice in Brick Pavement Construction," F. R. Williams, paving engineer of Cleveland, O.

"Traffic Census—Its Application to the Design of Roadways, Selection of Pavements and Traffic Regulation," D. B. Goodsell, assistant engineer, department of public works of the Borough of Manhattan, New York City.

"Earth and Gravel Road Maintenance," R. L. Morrison, Professor of Highway Engineering, Agricultural and Mechanical College of Texas.

The tentative program calls for the opening of the Eighth National Good Roads Show on February 5th. The registration of delegates and visitors will proceed during the day. In the evening the officers of the American Road Builders' Association will tender a formal reception to the exhibitors in the convention hall.

The first session of the congress will be called to order in the convention hall at 11 o'clock Tuesday morning, February 6th, by the president of the American Road Builders' Association. Governor S. W. McCall of Massachusetts and Mayor James M. Curley, of Boston, will welcome the delegates to the state and city respectively and other addresses will be made by Col. Wm. D. Sohier, chairman of the Massachusetts Highway Commission; Charles F. Weid, president of the Boston Chamber of Commerce, and George W. McNear, president of the Bay State Automobile Association. President A. W. Dean will make the response for the association.

Editorial

INTERESTING THE UNITED STATES IN CANADA.

Canada will no doubt have a tariff preference in all the markets of the British Empire after the war, and it seems reasonable to suppose that she will have at least a sympathetic preference in the countries that are allied with Great Britain. This will give Canada special opportunity for trade extension, particularly in the great empire of Russia.

According to Col. J. S. Dennis, president of the Canadian Society of Civil Engineers and assistant to the president of the Canadian Pacific Railway Co., these facts justify Canadians in extending an invitation to the people of the United States to establish more Canadian branches of United States industrial concerns, and to invest their money in the development of Canadian resources.

Col. Dennis is well known in the United States as an exponent of Canadian opportunities. He has spoken there frequently, and is now engaged in delivering a series of ten addresses entitled "Your Neighbors on the North," which give a complete outline of Canadian opportunities and resources.

This is important work of a sort which should be taken up by more engineers, because Canada will be very largely dependent on the United States for capital for some years after the war, and the true facts concerning our forests, mines, railways, municipalities, etc., can very frequently be explained by engineers to hard-headed business men and investors in a manner more convincing than could be done by more fluent but less accurately informed orators.

MONTREAL AQUEDUCT COMMISSION.

In an editorial in our January 18th issue we suggested that Sir Frederick Williams-Taylor be appointed as the business man and chairman of the commission to investigate the conflicting aqueduct reports presented by the city engineer and the ratepaying engineers of Montreal, and that the Montreal city council appoint one of the two engineers and the Canadian Society of Civil Engineers the other.

Our attention has now been called to the fact that Mr. Mercier had recommended the appointment of Messrs. Beaudry Leman, Henry Holgate and H. E. Vautelet, with Mr. Leman as chairman.

When the above-mentioned editorial was written, it was not known that Mr. Mercier had made such definite recommendations. As was stated in that editorial, no official copy of the report was available,—only the Montreal newspaper report of abstracts from it,—and this newspaper report had merely stated that Mr. Mercier had recommended the appointment of two engineers and one business man. *The Canadian Engineer* did not know that Mr. Leman had been mentioned for the position, and it was not our intention that he be displaced by Sir Frederick Williams-Taylor. Sir Frederick's name was mentioned only because he is the head of the bank which is conducting the city's financial affairs, and he should, therefore, be most intimately acquainted with what the city can afford and with the amount they have spent in the past. Mr. Leman would, no doubt, be quite satisfactory as chairman of the commission. As general manager of La Banque d'Hochelaga, he is undoubtedly familiar with Montreal's finances, and what information he lacks on account of his institution not being Montreal's official bank, would be made up by his engineering knowledge, as he is a B.Sc. of McGill University and of the University of Lille, France.

It is understood that the commission of three men, as recommended by Mr. Mercier, will really be appointed at an early date by the Board of Control. Either Sir Frederick Williams-Taylor or Mr. Leman should be a most satisfactory and open-minded chairman, but from the trend of affairs in Montreal at the present time, the commission may not include either of them.

The council of the Canadian Society of Civil Engineers should be permitted by the Board of Control to name one of the two remaining members of the commission, and Mr. Mercier should be asked to name the other.

CANADA'S RAILWAY PROBLEM.

W. F. Tye's paper on "Canada's Railway Problem and Its Solution," which has been presented to the Canadian Society of Civil Engineers, is a noteworthy contribution to Canadian economic and railway literature. It is far more than literature, however. It embodies great ideas, such as could have been evolved in a practical way only by a man of such vast experience and ripe judgment as Mr. Tye. Having been chief engineer of the Canadian Pacific Railway Company for many years, and with a long and varied engineering experience previously, Mr. Tye is unusually well qualified to discuss Canada's railway problem and its solution.

Mr. Tye undoubtedly has the detailed facts and figures on hand to back up all of his conclusions, and presumably would be willing to place them at the disposal of the properly constituted authorities when official attention is given to his article.

Mr. Tye's paper should not be merely read and fyled. It should be a live issue on the desks of Canada's Railway Board and of every member of Canada's Cabinet and Commons.

The twenty-three recommendations and the causes leading up to them should be carefully studied, not only by every politician, but also by every responsible government official in Canada. No doubt some will disagree with Mr. Tye's recommendations, but nobody can deny that there is food for reflection in what he says, and that the digestion of his report by all members of the government will be of ultimate benefit to the public.

NATIONAL BUSINESS CONVENTION.

The proposed National Business Convention, of which much was heard last year, is, it seems, to take place after all. It has been postponed so often that the impression became general that the conference would not be held. Sir

George Foster, however, in a recent interview in London said:—

"Much work has been done already and more must be done yet before the proposed Business Men's Convention in Canada can profitably meet. Meanwhile, public attention has been drawn to the objects for which the convention would meet. At present everybody is very busy and no one knows when the war will stop or what will be the conditions when it does stop. Everybody is thinking what can be done, but it is no good getting together until we have something definite to discuss, but in the meantime the matter has been brought to public attention and no ground has been lost."

Sir George is misled if he believes that many business men in Canada are doing any work in preparation for such a business convention or even thinking about the convention at all. The initiative, the preliminary plans and even the detailed plans of a successful national convention of this kind must—and should—all come from the government.

PERSONAL.

WILLIAM FORBES, of Woodstock, Ont., has been appointed superintendent of good roads in Oxford county.

GORDON McGREGOR was elected chairman of the Essex Border Utilities Commission at the recent inaugural meeting.

Lieut. PERCY VERE BINNS, a graduate in engineering of the University of Toronto, 1914, has been awarded the Military Cross for bravery.

JOHN ROBINSON has been appointed foreman of the eastern division of the county road system in McGillivary township to succeed J. D. DRUMMOND, who has resigned.

GEORGE H. DUGGAN, past president of the Canadian Society of Civil Engineers, has been elected a director of the Wayagamack Pulp and Paper Company, Montreal. Mr. Duggan left last night on a business trip to England.

J. G. CAMERON, C.E., of Berwick, Ont., has been appointed county superintendent over the extensive good roads scheme adopted by the counties of Stormont, Dundas and Glengarry, Ont.

Major V. L. MARSH, president of the Marsh, Hulton, Powers Co., contractors, New Westminster, B.C., has been appointed commanding officer of the railway construction corps to be raised in New Westminster.

RICHARD BELL, for many years head of the Sarnia waterworks system, was very seriously injured at the pumping station on January 23rd when his overcoat became caught in the revolving shaft of the big pumping engine.

B. G. MICHEL, A.M.Can.Soc.C.E., recently engineer for the town of Carleton Place and the corporation of the county of Lanark, Ont., has opened offices in the Bank of Toronto Building, Kitchener, Ont., for consulting practice in civil and sanitary engineering.

Major CHARLES FRANCIS HANINGTON, Mem. Can.Soc.C.E., of the 257th Railroad Construction Corps, has left Ottawa for St. John, N.B., where he will endeavor to raise a company of two hundred and fifty men in his native province and then proceed overseas with his regiment.

Dr. FRED. ADAMS, epidemiologist in the medical health laboratories, Toronto, has taken out a commission in the Canadian Army Medical Corps and has received orders to report for duty on February 1st. Dr. Adams was head of this division of the public health department during the absence of Dr. G. G. Nasmith in France.

GEO. H. PEGRAM, chief engineer of the Manhattan Elevated Railroad, was elected president of the American Society of Civil Engineers at the annual meeting in New York last week. He was born December 29th, 1855 at Council Bluffs, Iowa, and graduated from Washington University in 1877.

Major L. C. THOMSON, railway contractor, has been appointed recruiting officer in Montreal of the 257th Railway Construction Battalion, being raised by Lieut.-Col. L. T. Martin. Major Thomson has been engaged in railway construction work in the Maritime Provinces, Quebec and Ontario.

GEORGE T. DOUGLAS, of Amherst, N.S., until recently manager of the Amherst plant of the Canadian Car & Foundry Co., Limited, has been appointed assistant to the vice-president and managing director ot that company, and has left for England and France in connection with the company's export orders.

S. B. BENNETT, municipal engineer of South Vancouver, has resigned, and will leave for England about the end of February, where he has been appointed chemical engineer in a munition factory. Mr. Bennett went to British Columbia six years ago and was appointed city engineer of Nanaimo, but in 1914 was appointed to his present position in South Vancouver.

Lieut. C. S. L. HERTZBERG, A.M.Can.Soc.C.E., of Toronto, was wounded in the shoulder on January 21st. He was recently awarded the Military Cross for digging trenches under fire. He is a graduate of the School of Practical Science and went overseas with the Canadian Engineers. Lieut. Hertzberg is a son of Mr. A. L. Hertzberg, divisional engineer of the C.P.R.

OBITUARY.

ROBERT McBRIDE, of Vancouver, B.C., for the past ten years road superintendent for the province of British Columbia, passed away on January 22nd at the age of 58 years. He was born in Woodstock, Ont., and went to British Columbia 28 years ago.

CORRECTION.

Equation 14, page 52, January 18th issue of *The Canadian Engineer*, read $Md = + \varpi L/120$. This should have been $Md = + WL/120$.

COMING MEETINGS.

TENTH CHICAGO CEMENT SHOW, Coliseum, Chicago, Ill., February 7-15. Secretary, Blain S. Smith, 210 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE INSTITUTE. Hotel La Salle, Chicago, Ill., February 8-10, 1917. Secretary, Harold D. Hynds, 1418 Walnut Street, Philadelphia, Pa.

THE NATIONAL BUILDERS' SUPPLY ASSOCIATION. Annual meeting at the Hotel Sherman, Chicago, February 12-13, 1917. Secretary, L. F. Desmond, 1211 Chamber of Commerce, Chicago.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

BRUSHWOOD AS A MEDIUM FOR SEWAGE FILTERS

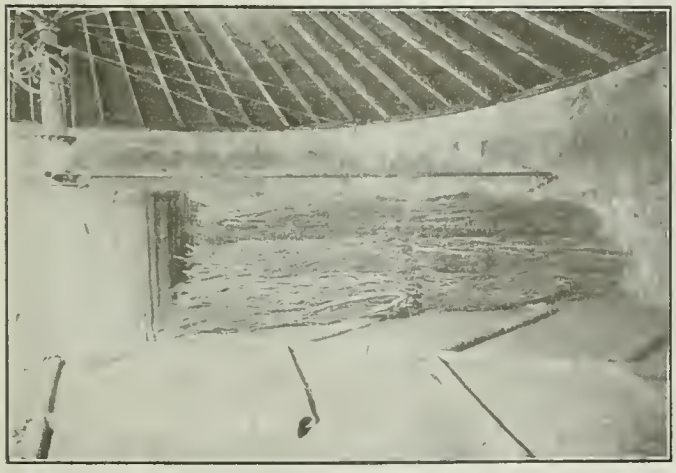
EXPERIMENTS AT NORTH TORONTO USING BRUSHWOOD AND SLAG AS FILTER MEDIA SHOW FORMER TO BE PARTICULARLY SUITABLE FOR INDUCING SLIMY GROWTH AND GIVING PROPER VENTILATION.

By GEORGE PHELPS, A.M.Can.Soc.C.E.,
Engineer in Charge of North Toronto Sewers and Disposal Works.

WITHIN the last two or three years, with the activated sludge process of sewage treatment coming so quickly to the front, engineers are beginning to look on the treatment of sewage by filtration as a somewhat slow process, and it seems probable that the filter will eventually be almost entirely discarded as new processes become perfected. In the meantime, filters are doing much good work, and any improvement in their efficiency is a step towards a solution of the sewage treatment problem. That there is room for considerable improvement in the character of medium ordinarily used is shown by the results obtained with an experimental filter, which has been in operation for 2½ years at the North Toronto sewage disposal works.

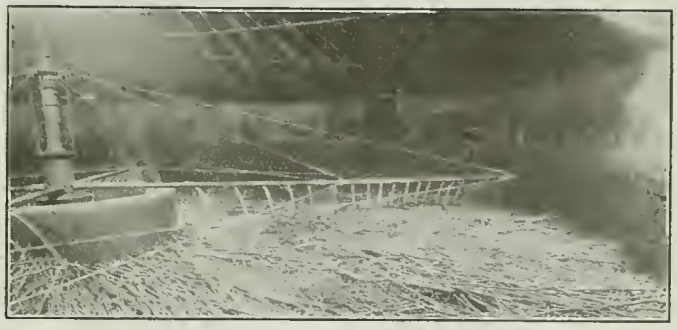
The sewage of that portion of the city, which was originally the town of North Toronto, is treated separately by disposal works, constructed before the annexation of this district to the city; it is a domestic sewage with practically no trade wastes, roof water being admitted to the sewers, but no other surface drainage.

It was found necessary in the early part of 1914 to clean out and refill some of the filters, and as an experiment, it was decided to use brushwood as a medium in one case, and for a second filter, screened, washed and graded slag, so that the two could be run under similar conditions and a fair comparison made between the results obtained. The depth of the medium in each case was 5 ft.



Brushwood Filter Under Construction.

6 ins., both filters being 50 ft. in diameter, and roofed over. The distributors are of the Adams rotary type. Before reaching the filters, the sewage passes through a coarse screen, detritus tanks and sedimentation tanks, the retention period in the tanks averaging about three hours.



Brushwood Filter in Operation.

The brushwood filter was started on June 3rd, 1914, at an average rate of flow of two million gallons per acre per day, and has been run continuously at varying rates up to the present time, with only a few short stoppages for alterations to the plant, the longest stop being for three days. There is a continuous and fairly constant flow to the filter, the maximum and minimum rate for any day being about 10% above and below the average.

After two months' working, the brushwood had become thickly coated with gray slime and a very satisfactory effluent was obtained, and from that time on, the flow to the filter has been periodically increased up to the present average rate of 7,250,000 gallons per acre per day. The following table shows the average daily rates from the time of starting the filter, *viz.*:—

June to August, 1914	2,000,000	gallons per acre
August to October, 1914	3,000,000	" "
October to November, 1914..	4,000,000	" "
November to December, 1914	4,500,000	" "
December to February, 1915.	5,000,000	" "
February to April, 1915	5,500,000	" "
April to September, 1915 ...	6,000,000	" "
September to July, 1916	6,500,000	" "
July to December, 1916	6,900,000	" "
December, 1916, to date	7,250,000	" "

The sewage passes through the filter at the present rate as freely as when it was first started. The coating of slime on the brushwood is in a condition of stability where it appears neither to increase nor diminish, and, as there is no sign of clogging, it is probable that the flow may yet be somewhat increased. The most noticeable change which took place was the shrinking of the brushwood, which in a few months settled down until the depth of medium was only about 4 ft. 6 ins. This shrinking apparently stopped after about 18 months working, and

Forming a Mattress.

the brushwood shows no signs as yet of rotting or breaking down.

The slag filter, which has been kept under observation alongside the brushwood, is filled with washed and screened steel slag, graded as follows:—

Bottom,	1 ft. 0 in.,	3-inch to 5-inch slag
Middle,	3 ft. 0 in.,	1½-inch to 3-inch slag
Top,	1 ft. 6 in.,	⅝-inch to 1½-inch slag

It was started at a rate of 1¼ million gallons per acre per day, and worked up to 2½ millions in 6 months; the rate was increased for a short time to 3 millions, but this resulted in clogging and ponding on the surface, and the rate had consequently to be reduced. The effluent from this filter has always been satisfactory, but its capacity is limited to about 2 million gallons per acre per day, the rate at which the sewage will pass through without clogging.

The effluent from both filters contains usually from .1 to .2 cubic centimetre of sediment per litre; this is a fine humus which is settled out by a half-hour retention in tanks; it is liable to increase with sudden rushes of storm water, but is easily got rid of.

Samples of sewage and effluents have been taken regularly five days in the week, until three months ago, since when samples have been taken on only two days in the week. These are always taken between 10 a.m. and 12 noon—about the time of maximum flow. Analyses are made in the laboratory of the Medical Health Department of the city, and the following tables give the average results obtained, *viz.*:—

January to December, 1915.

	Free amm.	Alb. amm.	Putrescibility.	Nitrates.
Tank effluent	12.63	2.83	32	
Brush filter effluent	10.70	1.52	95.7	
Slag filter effluent.	4.13	1.09	98.4	

December, 1915, to May, 1916.

	Free amm.	Alb. amm.	Putrescibility.	Nitrates.
Raw sewage	12.50	3.84	..	2.36
Tank effluent	11.45	3.06	32	2.50
Brush filter effluent	10.59	1.56	90	2.55
Slag filter effluent.	5.37	1.34	98	6.00

May to November, 1916.

	Free amm.	Alb. amm.	Putrescibility.	Nitrates.
Raw sewage	27.6	7.92	..	
Tank effluent	22.3	3.94	35	
Brush filter effluent	16.9	2.41	99.7	
Slag filter effluent.	11.4	2.20	100	

The methylene blue test is used for putrescibility, and value 100 equals stability for 10 days.

The filter effluents are settled for one-half hour before analysis.

Although the sewage is getting stronger in character, as shown by the average results for the last six-monthly period, the effluent from the brushwood filter is more stable than it previously has been, and the rate of flow at the same time is greater. This seems to indicate that the filter has not yet reached the limit of its capacity. The only tests for nitrates were taken during March and April, 1916. The average results given in the table go to show that nitrates are not formed in the brushwood as readily as in the slag filter, which is no doubt due to the rapidity with which the sewage passes through the brushwood. Unfortunately, this period included the time of the spring thaw, and the sewage was very much diluted. The filter was also taking considerably over 7,000,000 gallons per acre per day for practically the whole of the two months, so that further tests are necessary before a definite opinion can be formed on this point.

The accompanying photographs show the method of making and placing the brushwood mattresses in the filter, also the filter in operation and a section whilst under construction. The floor, as will be seen, is formed with a

Removing Mattress from Press.

slope each way to the under drains. The brushwood is placed in the filter in the form of mattresses of 2 cubic yards each. These were made by filling the brush into a wooden box of the required shape, and pressing it down with a follower on a long lever. The mattresses were wired up whilst under a pressure of about 80 lbs. per square foot, and after this was released the shape was retained and they were easily handled. Witch hazel was found to be the best material for making up, but almost any kind of brush is suitable, provided no dead wood is

used. It requires to be cut in the fall or early spring when no leaves are on. The cost of cutting, bundling, hauling about half a mile and placing the brushwood in the filter was $1.20 per cubic yard, a figure much below that for which any ordinary medium could be obtained. The results have been so satisfactory that brushwood as a medium is being used generally at the North Toronto plants, when any filter needs refilling. The open nature

Putting Brushwood Into Press.

of the brush allows good aeration, and it is very efficient when working at a high rate of flow. The rotary distributor also seems well adapted for this type of filter. It gives a good distribution, does not require a great deal of attention and requires only about a foot of head for its operation.

For small installations, particularly where operating charges are of great importance, it may be a long time before the activated sludge process with the introduction of power that it entails, can compare favorably in cost of construction and maintenance with a plant consisting of sedimentation tanks and brushwood filters. Furthermore, an examination of the two processes will show that they are not so different in principle as at first sight they appear to be.

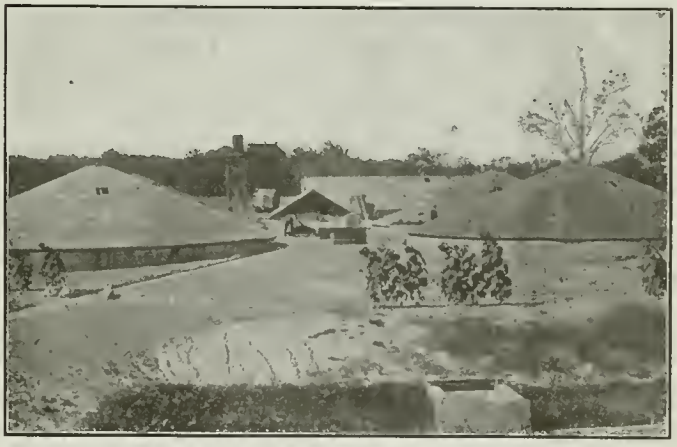
The activated sludge process by the mechanical aeration of sewage induces the growth of organisms on particles of sludge and by a mixing process brings these sludge particles into contact with all parts of the sewage, so accomplishing the process of oxidation and nitrification. The percolating filter accomplishes the same purpose by the reverse process, the organisms being stationary on the medium of the filter and the sewage brought into contact by trickling over the gelatinous substance in which they are contained.

Most recent methods of sewage disposal show that the three main conditions necessary for the effective purification of sewage are: Sufficient aeration, a suitable medium for the growth of nitrifying organisms, which must be brought into intimate contact with all parts of the sewage, and the maintenance of the sewage at a moderate temperature. In the activated sludge process the introduction of the necessary power and machinery for air compressing adds very much to the operating costs, and any process which would automatically maintain the required conditions would naturally recommend itself, provided that the results were satisfactory. The above experiment has shown that the brushwood filter maintains fairly well the conditions set out above, without the introduction of power. Constructed with a good system of underdrains and with a space between the walls of the filter and the brushwood mattresses, the air has very free circulation throughout. The brushwood does not get compacted or lose its spring but keeps quite open, and given proper ventilation, with the falling of a large volume of sewage through the filter, the air contained is constantly being changed.

Brushwood also shows itself to be particularly suitable as a medium for inducing the slimy growth characteristic of sewage filters. The thick coating of this slime over every particle of the brush is in marked contrast to anything that can be seen on a medium such as stone or slag. Regarding temperature, it should be noted that the sewage at the experimental plant does not fall below 40° Fahr. in the winter, and rises to a maximum of 58° Fahr. in the summer; and, as the tanks and filters are all covered, the effluent leaves the plant at about the same temperature as the sewage enters. The temperature of the air at 4 feet above the surface of the filter is noted every day and only occasionally in the coldest weather does it fall as low as 36° Fahr. The temperature of the filter medium can be taken as that of the sewage itself; that it, usually ranging between 40° and 50° Fahr., a favorable working temperature which has probably an important bearing on the efficiency of the filter.

To engineers constructing filters of this type, it is recommended that they be made at least 7 feet deep if possible, and made up to this depth again when the bed has been in work for 12 or 18 months, in which time it will have shrunk down considerably. Nothing has been added to the one described since it was started, not because it is inadvisable, but because it would break the continuity of the experiment. A deeper filter would give the sewage a longer time in contact with the medium and should give better nitrification. A 7-foot deep filter could probably be worked efficiently up to 8 or 9 million gallons per acre per day.

The writer is of the opinion that a brushwood filter would satisfactorily treat raw sewage after passing through a coarse screen and detritus tank, without a preliminary treatment in sedimentation tanks at something approaching the rate of working obtained in the above plant, provided that the effluent were passed through a suitable humus tank, and we hope to be able to continue the experiment along these lines. Such a filter



Filters at North Toronto Sewage Disposal Plant.

might be constructed on a coarse grating over a two-story tank having a deep sludge digestion chamber, free air space being allowed all round, under and above the filter, the sewage falling through the filter directly into the tank. After sewage has been aerated, the suspended solids quickly settle out, and a retention period of one-

half hour in the tank should be sufficient to give an effluent fairly free of suspended matter. The sludge and humus would be collected in the same digestion chamber and might be drawn off under hydraulic head in the manner usual with two-story tanks.

The principle of treatment of sewage in sedimentation tanks followed by percolating filters has been criticized on the ground that, during its passage through the sewers aerobic bacteria are developed in the sewage and the process which is started there is reversed in the sedimentation tanks where anaerobic bacteria are developed, to be reversed again in passing through the filters, which is a distinctly aerobic process. The part played by aerobic bacteria in the sewers is open to question, but there is no doubt that the treatment of sewage by filtration after it has passed through sedimentation tanks is a change over from the anaerobic to the aerobic process. A method which would eliminate the first sedimentation tank as here suggested would not be open to this objection, and the removal of what is apparently a check in the process might help towards the attainment of good results.

The brushwood filter described, which has been a decided success, is virtually the outcome of previous experiments with a lath filter originated by Lieut.-Col. G. G. Nasmith, C.M.G. The writer has been in charge of the construction and operation of the filter under Mr. W. R. Worthington, of the sewer section, Department of Works, Toronto, of which Mr. R. C. Harris is the commissioner.

ANNUAL CONFERENCE OF COUNTY ROAD SUPERINTENDENTS OF ONTARIO.

The programme for the next annual conference of county road superintendents of Ontario, the sessions of which will be held in the Parliament Buildings, Toronto, is as follows:—

Tuesday, March 27.—Morning Session: "Departmental Requirements Regarding Annual Returns," Mr. W. Huber, Assoc.Mem.Can.Soc.C.E. Records and annual statements of expenditures on highways towards which the provincial subsidy is paid are required to be shown in a manner specified by the department.

Afternoon Session: "The Transportation of Materials," Mr. Geo. Hogarth, O.L.S., Assoc.Mem.Can. Soc.C.E., Provincial Engineer of Highways. The greater portion of the cost of road-building materials is that paid for transportation. Economical haulage is of vital importance in the reduction of the cost of roads. "Maintaining Earth and Clay Roads," Mr. A. A. Smith. The keeping of unimproved portions of the county road systems in a passable condition is of as great importance as the maintenance of roads after construction.

Wednesday, March 28.—Morning Session: "Highway Bridges," Mr. Geo. Hogarth, O.L.S., Assoc.Mem. Can.Soc.C.E. The department has prepared standard plans and specifications for steel and concrete bridges, which are available for the use of county road superintendents and engineers. "Culverts," Mr. Arthur Sedgwick. There are a number of types of culverts, each being best adapted to certain conditions.

Afternoon Session: "Dust Preventatives and Bituminous Binders," Mr. G. C. Parker, B.A.Sc., Assoc. Mem.Can.Soc.C.E. Dust on a metalled road indicates wear, and its prevention by the use of bituminous materials, properly chosen, results in greater comfort to users of the highways as well as a reduction of maintenance costs. "Important Details in Oiling and Tarring," Mr. W. Huber, Assoc.Mem.Can.Soc.C.E. Expenditure for good materials is wasted if care is not exercised in the preparation of the road surface and the methods of application.

Thursday, March 29.—Morning Session: "The Highways Laws of Ontario," Mr. W. A. McLean, Member Can.Soc.C.E., Deputy Minister of Highways. County road superintendents should be well versed in the legislation under which they operate, in order that they may advise their municipal councils with respect to proper procedure.

Afternoon Session: "Increasing the Safety of Highways," Mr. W. H. Losee, B.Sc. Many accidents could be avoided by the elimination of level railroad crossings or, where that is impossible, the removal of obstacles obstructing the view of those using the roads. "Repairing Gravel and Stone Roads," Mr. R. M. Smith, B.Sc. A thorough system of caring for gravel and stone roads should be adopted immediately following their construction.

Friday, March 30.—Morning Session: "Reducing Construction Costs by Increased Efficiency," Mr. W. Huber, Assoc.Mem.Can.Soc.C.E. Approximately one-half of the cost of a highway is that of labor. The elimination of wasted time and energy is the first step towards lowering the cost of construction.

Afternoon Session: "Roads Foundations and Drains," Mr. R. C. Muir, A.M.Inst.C.E., Assoc.Mem.Can.Soc. C.E. The bearing power of a subgrade depends on the efficiency of the drainage system. The subjects of foundations and drainage are closely allied. "Concrete Roads," Mr. H. S. Van Scoyoc, chief engineer, Toronto-Hamilton Highway Commission. When used in a road surface, concrete is subjected to severe conditions. It is essential, therefore, that only the best materials be used and careful methods of construction be followed.

AMERICAN CONCRETE PIPE ASSOCIATION.

The annual convention of the American Concrete Pipe Association will be held in the Auditorium Hotel, Chicago, on February 12, 13 and 14, 1917.

Among the papers which will be read are the following: "Supporting Strength of Drain Tile in Ditches," by W. J. Schlick, drainage engineer, Iowa State College; "New Drain Tile Specifications of the American Society for Testing Materials," by George P. Diekmann, chief chemist, Northwestern States Portland Cement Co., Mason City, Iowa; "Concrete for Sanitary Sewers," by M. W. Loving, Universal Portland Cement Co.; "Aggregates for Sewer Pipe and Drain Tile," by Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill.

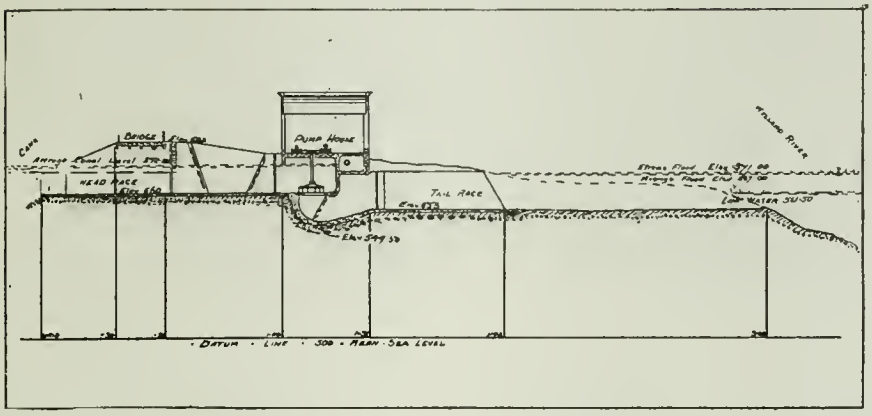
ROLLING STOCK FOR FRENCH RAILWAYS.

According to a French contemporary, the Germans have carried away some 55,000 railway vehicles from France, and in order to make good the shortage orders for new stock have been placed in America and Spain by the Government. The first batch of 5,000 vehicles was ordered at the beginning of 1915, and 3,400 of these are already in service. About 7,000 are being erected in the railway companies' workshops and 200 by private firms, who received the parts and are making the bodywork. Orders have been placed with French firms when they were ready to accept them.

WATERWORKS DEVELOPMENTS, WELLAND, ONTARIO.

By D. T. Black, Town Engineer.

THE commencement of the construction of the large stone aqueduct at Welland, Ont., still in use on the present canal, brought contractors, tradesmen and a large number of laborers to the then quiet county town. The temporary increase in population caused a moderate building boom, introduced new life and a desire amongst the citizens to possess some local improvements employed at that time in other towns.



General Section. New Pumping Station, Welland.

The council of 1887 was a very energetic one, and in the council minutes, three items of importance are recorded; the construction of the first sewer; the erection of several electric arc lamps to replace the old coal oil street lights, and the passing of a by-law by the people for the installation of a water supply.

The first Welland water supply was completed in 1888, and consisted of supply pipe, filter, pumping station, distribution mains, hydrants and some fire hose, at a cost of $48,000.

The filter and pumping station are situated about one-quarter of a mile west from the present canal, and on the south side of the river. The source of supply was from the Welland Canal by means of a 12-inch pipe. The power was water from the government raceway, which passed the site chosen for the pumping station. The tailrace discharged to the river close by.

The supply pipe fed the filter and had a by-pass pipe direct to the pumps. The filter measured 50 feet by 36 feet wide, and the filtering material was sand and graded gravel. The filtered water was collected into a well under pumps.

The pumps consisted of two sets of three plunger pumps each, and received power from two turbine wheels, one for each set of pumps. The headrace water was drawn from the raceway and had wooden racks and a set of stop-logs. The average head of water measured from surface in raceway to surface of river was 9 feet. The turbine wheel gates were controlled from the pump-house. Each set of pumps was alike in design, and were erected by Wm. Kennedy & Sons. One set was rated at a quarter million gallons each plunger, or a total of three-quarters of a million gallons; the other set was rated at a half million gallons each plunger, or one and one-half million gallons each. The power from the wheels was transmitted by steel shafts and gearing and both sets could be operated in conjunction with each other by means of a slip-bolt coupling on the main gear shaft. The pumps were supplied with air vessels, gauges, etc. Three years later, a 50-h.p. engine, fed from two tubular boilers, was erected to assist the pumps when water was low or when frazil ice interfered with the wheels. The wheels and pumps are still used at odd times, but the engine has been out of use for some time past. This plant did good service until 1912, when the new station was completed.

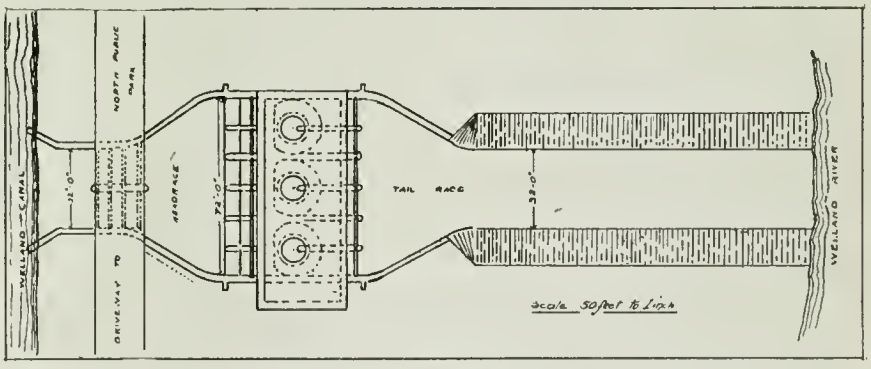
Mr. Wm. Kennedy, Jr., Montreal, designed the new pumping station, and the entire construction was carried through by the town engineer.

The new station is situated on what is known as the Island, a narrow strip of land near the centre of the town, and north of the aqueduct. This strip of land is bounded on the west by the Welland Canal, which supplies the water power and is the source of supply. The east boundary is the Welland River, into which the tailrace water flows. The total cost of the building, machinery and new water mains was $75,000.

The most interesting part of the construction was the concrete foundations and substructure, intricate in design to obtain the maximum power from the head obtainable.

The foundations, walls and floors were 1:3:5 concrete in mass formation, and where reduced in thickness were 1:2:4 reinforced with steel rods. The pump-house floors were 1:2:4 reinforced concrete.

The substructure consisted of penstocks, three wheel chambers and wheel pits. The intake works consisted of two channels each 16 feet wide, 85 feet long, having a bridge roof 20 feet wide. Each channel from bridge floor to channel floor is 22 feet, and has an average depth of 12 feet of water. Each channel is provided with a set of stop-logs and stop-log lifts. The headrace is 72 feet at its widest part. The penstocks are provided with steel racks and stop-logs. The three wheel chambers are each 22 feet in diameter, and are entirely separate, one for each pumping unit. Stop-logs are provided for emergency between wheel pits and tailrace. The tailrace, also built in concrete, is 135 feet long and 32 feet wide.



General Plan of New Pumping Station, Welland.

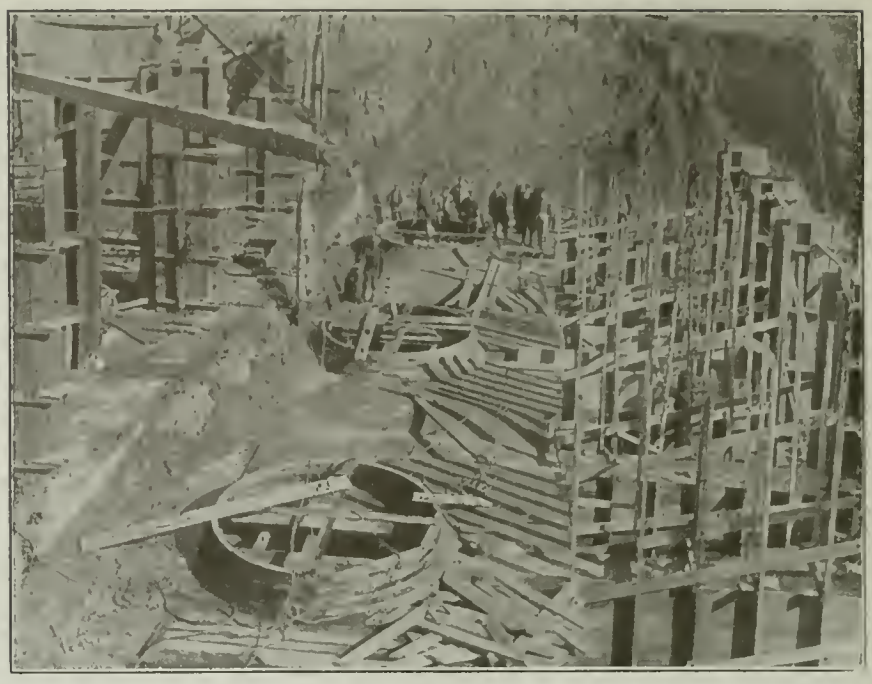
The turbine wheel installed for the first unit was manufactured by the Jens Orten-Boving & Co., London. It is rated at 250 brake horse-power, measures about 10

feet in diameter, and under 8 feet head of water, measured from headrace water surface to tailrace water surface, when the wheel is running at 28 revolutions per minute, has ample capacity to work the pumps continuously when they are discharging three million Imperial gallons of water daily against a pressure of 120 lbs. per square inch in the air vessel.

The water-wheel runner and shaft are supported entirely by a bearing on the top of the wheel case, thus doing away with the necessity of cross-arms and foot steps beneath the runner. The hand-operated water-wheel gate moving apparatus has a graduated indicator showing the percentage of total gate opening and the number of square inches the gates are open.

There are three horizontal single-acting, outside packed plunger pumps; the bed plates of which are connected together; placed around the top of the turbine shaft at angles of 120 degrees each between the pumps. The pump plungers are driven by three connecting rods, directly connected to one crank on top of the 8⅝ inches diameter turbine shaft. Securing the advantages of three throw plunger pumps without the friction losses of gears and cost of up-keep.

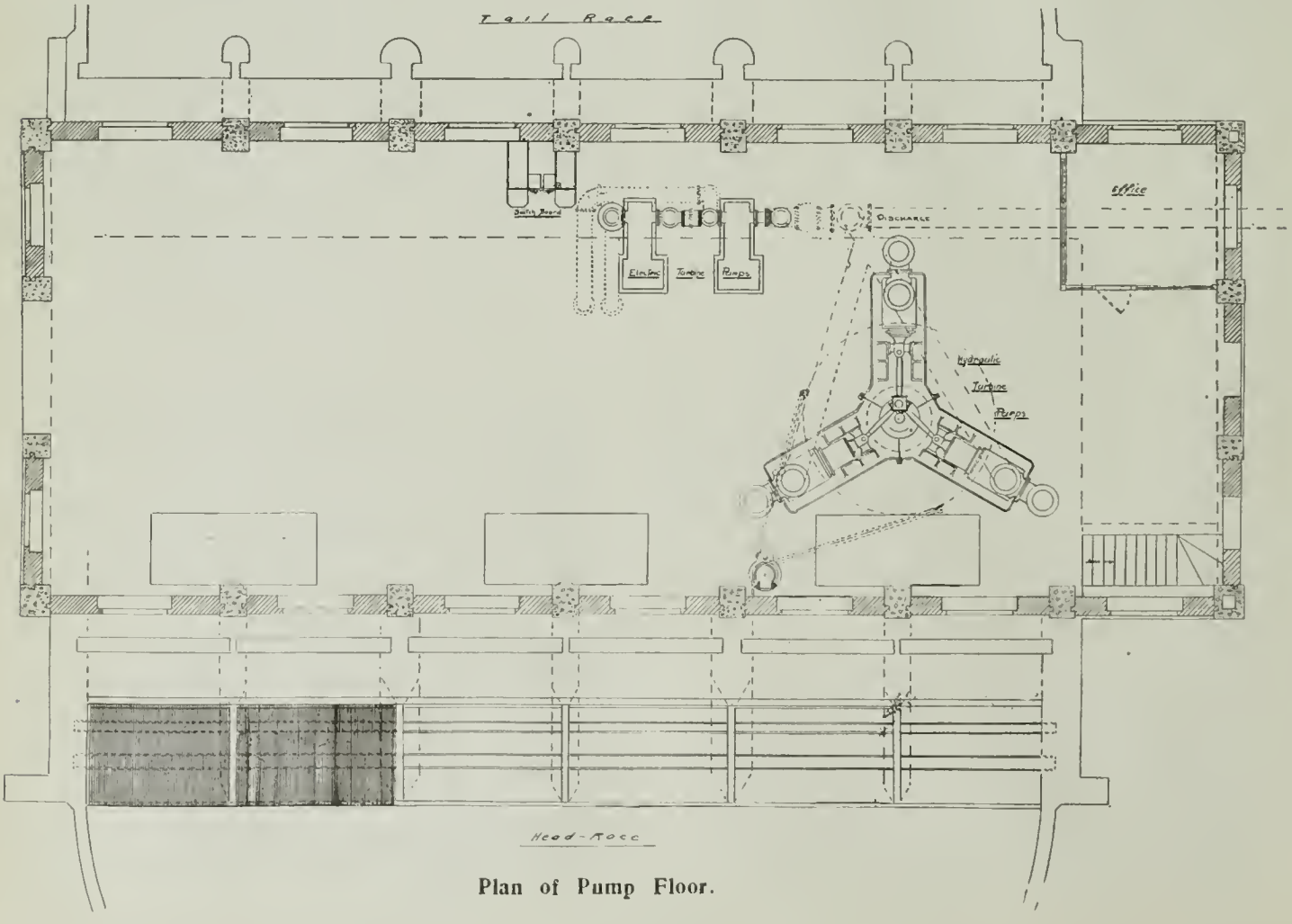
The pumps were manufactured by Messrs. Frank Pearn Co., Limited, Manchester, England.



Showing Draft Tube from Wheel Chamber, Welland Pumping Station.

There are three suction pipes, one to each pump cylinder with reflux valve and screen on each.

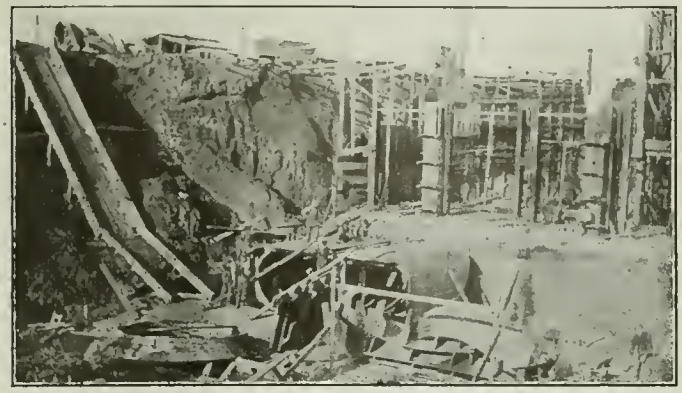
The discharge pipes from the three pumps are connected to one pipe with an air vessel at the junction.



Plan of Pump Floor.

These pipes have a stop valve between the air vessel and main discharge pipe to the town main.

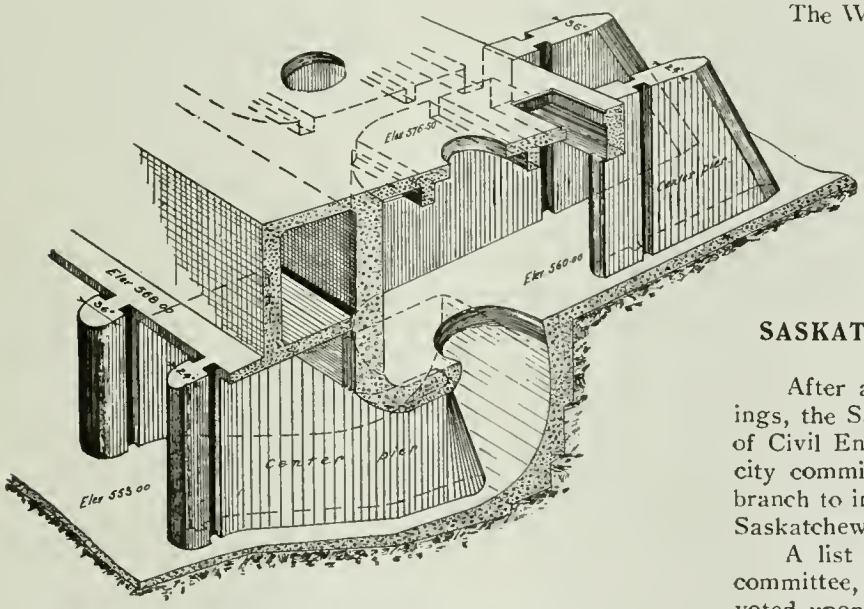
The pumps are fitted with glass water gauges, pressure gauges, revolution counter, etc. The whole forms one complete unit, with provisions for two other



Showing Wheel-Pit Forms, Welland Pumping Station.

units, so arranged to work separately from, or in conjunction with each other.

The pumping station building measures 93 feet long, 38 feet wide and 23 feet from floor to ceiling. The walls are faced externally with No. 1 Milton brick, internally with white enamelled brick 6 feet above the floor and light buff brick to ceiling. The roof is flat of double construction, with air space. The outer roof is constructed



Perspective Sketch Through Substructure Section. Taken Immediately in Front of New Pier.

of timber covered with 3-ply Brantford roofing felt and tar and gravel; the inner roof is 6 inches thick of reinforced concrete, supported on heavy I-beams, and smoothly finished inside. The windows are 11 ft. 6 ins. by 4 ft. 6 ins., and have Finestra steel sashes; the window sills are grey marble slabs. A 10-ton hand-operated travelling crane to work longitudinally the length of the building was installed. The office is fitted with telephone, fire alarm bell and loud pump pressure alarm bell. The station was completed early in 1912. In 1914 the Turbine Equipment Co., Limited, Toronto, were given the contract to erect two additional electrically driven centrifugal pumps to relieve the water power pumps during trouble with frazil ice, and assist the pressure at other times. This installation consists of two separate pumps to work separately or in conjunction with each other and also in conjunction with water power pumps.

The pumps are De Laval, single-stage, double-action centrifugal, and are rated to deliver 2½ million gallons each in 24 hours, at a speed of 1,890 revolutions per minute, against a pressure of 70 lbs. and when working in series against a pressure of 110 lbs. Each pump and motor is mounted on one box bed and connected with a forged steel shaft and flexible coupling. The impellers are of the enclosed double-suction type of the non-overloading design and each as well as the protecting rings are made of government bronze. The suction pipes have a suction head of 15 feet and receive supply from the wheel chamber for No. 2 unit. The discharge pipes are connected together, and fitted with a complete set of valves for separate control; the necessary pressure gauges, etc., complete.

The motors are spiral cage, Canadian Crocker-Wheeler, 125 brake horse-power each, 2,200 volts, 60-cycle, 3-phase, 1,890 r.p.m. with switch-board complete.

The total water mains laid up to 1916 within the corporation limits was 25¾ miles, from 4-inch diameter to 16-inch diameter, with an extra 1½ miles outside the town limits. During 1916, 731,174,560 Imperial gallons were pumped. This large quantity is accounted for by the heavy consumption in the steel plants, which chiefly form Welland's industries.

The Welland Water Commission was formed in 1908, and took control of the waterworks which previously was managed by a committee of the town council. Since the formation of the commission Mr. Robert Cooper has been returned continuously as the chairman, and is deeply interested in the development of the system. The superintendent is Mr. F. D. Milo.

SASKATCHEWAN DIVISION, CAN. SOC. C. E.

After a number of organizing and committee meetings, the Saskatchewan Division of the Canadian Society of Civil Engineers was formed at a meeting held in the city commissioner's office at Regina, January 30th, the branch to include every member of the society residing in Saskatchewan.

A list of officers was presented by the nominating committee, to be submitted by letter ballot, which will be voted upon at the next regular meeting. The following are the nominations: For chairman, L. A. Thornton, Regina; vice-chairman, G. D. Mackie, Moose Jaw; executive committee, H. S. Carpenter and E. G. Montgomery, Regina, T. C. MacNabb, Moose Jaw, Prof. A. R. Greig and C. J. Yorath, Saskatoon; secretary-treasurer, J. N. deStein, Regina.

Besides the regular meetings, a large summer meeting will be held alternately in the various centres of the province, for this year Saskatoon having been chosen.

An advisory Board will be nominated to represent each branch of the engineering profession in the province. This board will give professional advice to members requiring such and will also report to the council in all matters where the standing of the profession is involved.

NOTES ON EXPERIMENTS WITH ACTIVATED SLUDGE PROCESS AT REGINA.

By J. Russell Ellis, Acting City Engineer.

THE reasons for instituting the experiments were as follows: (1) To establish the practicability of the process under our local conditions; (2) to obtain data which could be applied in the design of a large scale plant if it should be considered feasible to proceed to this extent.

In May, 1915, the work was started by erecting two galvanized iron cylindrical tanks each 4 ft. 6 ins. in diameter by 5 ft. 10 ins. high in the city power house. The capacity of each tank when filled is 92.72 cu. ft., or 577.8 Imperial gallons. A small pump, an air compressor and an air tank were secured. Experimental tank No. 1 was filled up as follows:—

A 1-in. galvanized iron pipe leads from the compressed air tank to the tank No. 1, but before entering this branches into three ½-in. pipes. One of these branches is carried down inside the tank and across the bottom to a dead end. The other two are carried down one side of the tank, across the bottom, up the other side and back across at the top, being connected to form complete circuits. At the bottom of the tanks the pipes are perforated and covered over with canvas, as shown in the drawing. In the 1-in. air supply pipe a ⅜-in. orifice is inserted, the difference in pressure on the two sides of which is measured by the connected water gauge, and from the gauge readings the consumption of air is readily calculated.

In tank No. 2 the pump draws sewage from the bottom of the tank through a pipe which connects with the tank, and discharges it through a pipe leading down through the top of the tank and ending immediately above a galvanized iron cone, which disperses the sewage as it is discharged. An air injector is formed in the discharge pipe just above the tank by reducing the sectional area of the pipe and connecting this section of the pipe with an air orifice of ⅜ in. diameter. The difference in pressure on the two sides of this orifice is indicated by a water gauge connected to the orifice pipe and the air consumption is calculated from the gauge readings.

Sewage is supplied to both tanks through a supply pipe connected to a force main in the pump-house. The effluent is siphoned from the tanks through a siphon installed in each tank, as indicated on the plan.

Tank No. 1 was placed in operation on May 18th and tank No. 2 May 20th, 1915. After a short period of operation, chemical tests revealed results as follows:—

	Raw sewage.	Tank No. 1.	Tank No. 2.
May 17	0.0000432	.....	.....
May 22	435	0.0000460	0.0000509
May 24	...	464	659
May 26	...	737	903
May 27	...	940	1186
May 29	...	1160	1334
May 31	...	1165	1250
June 1	...	1249	1255

The difference in the results from the two tanks is due to the continued circulation of the sewage in tank No. 2 developing greater heat than the other tank.

The following data in connection with the operation was recorded:—

	Quantity of air in cu. ft. per min.			Temperatures, in degrees Fahr.	
	Tank 1.	Tank 2.	Air.	Tank 1.	Tank 2.
May 18 ..	3.96	....	55	48	..
May 19 ..	3.60	....	56	52	..
May 20 ..	4.40	....	66	55	58
May 21 ..	4.40	5.08	66	57	76
*May 22 ..	4.47	5.08	69	60	84
May 23 ..	5.18	5.76	72	60	90
May 24 ..	5.08	5.08	70	61	92
†May 25 ..	4.30	2.72	69	67	87
†May 26 ..	4.90	4.07	62	67	83
†May 27 ..	4.90	4.50	67	67	87
May 28 ..	5.26	4.50	64	67	87
May 29 ..	5.26	4.70	68	68	87
May 30 ..	4.40	4.50	73	68	86
†May 31 ..	4.70	4.30	72	68	87
June 1 ...	4.30	4.30	74	68	87
June 2 ...	4.07	4.07	73	68	85

*Pail of concentrated sewage added to No. 2.

†Pail of concentrated sewage added to each.

When the fresh sewage was added to the tanks it was transmuted into odorless matters in a very short time. The sewage first turned clear with a black sediment having a mossy odor, and later became brownish in color with a light brown sediment. When this stage was reached the sewage was found to be stable and non-putrescible.

After the foregoing series of tests the experimental plant was transferred to the sewage disposal works, and re-erected in the pump-house there. It was then operated by the regular attendants, the tanks being filled and drawn during cycles of about six hours. This was continued for several months, and the results appeared to be highly satisfactory.

	Free Ammonia			Albuminoid Ammonia			Nitrites			Nitrates			Oxygen Consumed	
	Raw Sewage	Tank 1	Tank 2	Raw Sewage	Tank 1	Tank 2	Raw Sewage	Tank 1	Tank 2	Raw Sewage	Tank 1	Tank 2	Tank 1	Tank 2
May 22-26	....	7.69	6.50	....	2.84	1.026	....	0.990	0.495	....	0.485	0.980	....	....
May 31 ...	1.009	....	....	16.03	....	....	....	....	....	0.23	4.32	8.98	....	....
June 1	....	....	....	....	trace	trace	....	.. .	....	....	6.72	8.98	0.75	0.80
June 7	....	....	....	....	....	....	....	....	....	....	8.20	8.98	....	....

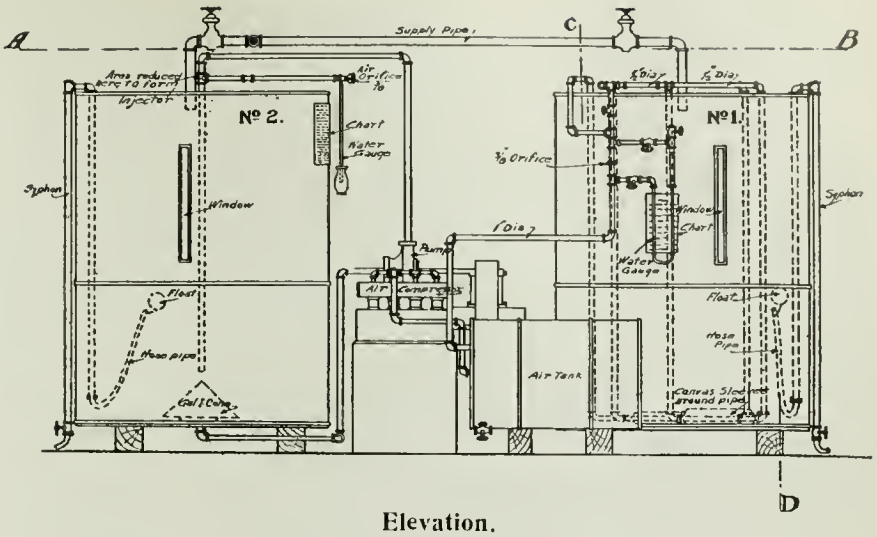
All quantities are given in parts per 100,000.

In addition to these tests the chemist made several observations to determine the relative amount of mineral salts by measuring the electrical conductivity of the sewage. The average conductivity of the city water as previously determined was stated to be 0.0000406 (not

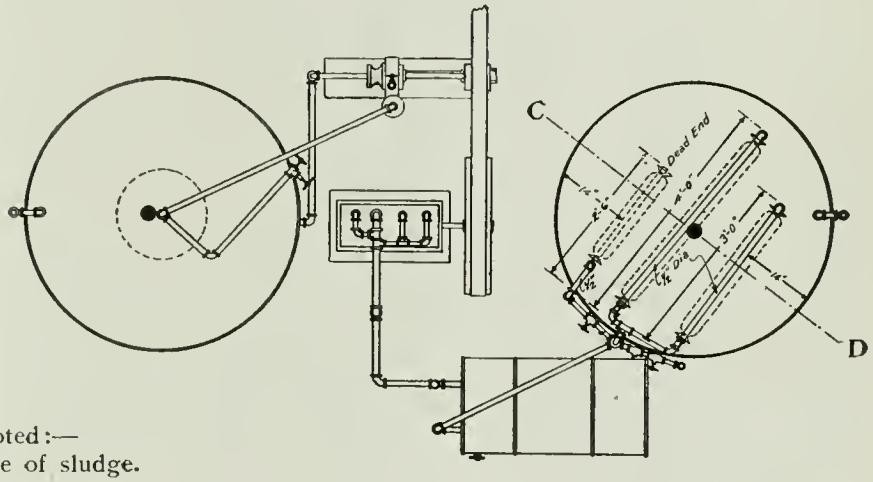
Near the end of the year it became necessary to rearrange the apparatus, and change the motor driving the pump and air compressor. After this lapse the tanks were

cleaned out and the experiments started again. Beginning January 12, 1916, operation was begun on a twelve-hour cycle; *i.e.*, ten hours for aeration, and two hours for settling, drawing and filling. It was planned to gradually reduce this time as the sludge deposit increased until the minimum period required for obtaining the desired purification was found. The air pressures, volumes of sewage treated, temperatures of sewage before and after each filling and the room temperature were recorded. During January and February the room temperature ranged from 38 degrees to 46 degrees, the temperature of the fresh sewage entering the tanks from 46 degrees to 50 degrees and the temperature after aeration from 40 degrees to 47 degrees, showing an average loss of 7 degrees in tank No. 1 and 6.3 degrees in tank No. 2 during the aeration period.

The tanks were operated continuously from January 12th to February 15th, being then closed down till February 20th for repairs to pump and motor. Tank No. 1 was in operation from February 20th to March 2nd, and tank No. 2 from February 20th to February 25th. Both tanks were operated from March 13th to April 24th, from April 27th to May 5th and from May 13th to June 5th. The idle periods were due to the adjustments and repairs required to the apparatus. The time of the staff during the summer was entirely taken up with the press of the summer work. On April 5th the cycle was reduced from 12 hours to 10 hours.



Elevation.



Section at A.B.

The following are some of the results noted:—

	Percentage of sludge. Tank 1.	Tank 2.
March 2	8.6%	3.9%
March 10	8.5%	...
March 31	13.8%	10.5%

Chemical Tests.

Raw Sewage.

	Oxygen absorbed, in pts. per 100,000.	Nitrites, in parts per 100,000.	Nitrates, in parts per 100,000.
February 5	3.0	none	none
February 7	2.4	none	none
February 10	3.5	none	no test
February 11	3.0	none	no test
March 29	3.7	none	none
April 4	3.0	none	0.7

Effluent from Tank No. 1.

	Oxygen absorbed, in pts. per 100,000.	Nitrites, in parts per 100,000.	Nitrates, in parts per 100,000.
February 5	1.1	.1	.3
February 7	1.1	.3	.4
February 10	1.2	.3	no test
February 11	1.2	.1	no test
March 29	2.0	0.5	0.5
April 4	1.2	0.8	0.5

Effluent from Tank No. 2.

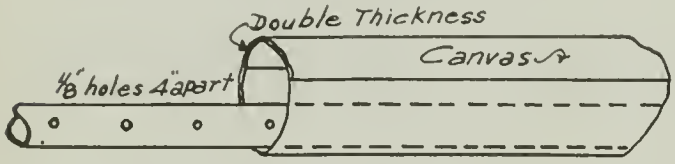
	Oxygen absorbed, in pts. per 100,000.	Nitrites, in parts per 100,000.	Nitrates, in parts per 100,000.
February 5	1.3	.1	.5
February 7	1.2	.3	.3
February 10	1.2	.2	no test
February 11	1.3	.2	no test
March 29	1.5	.7	.8
April 4	1.5	.8	.8

Relative Stability, in Days.

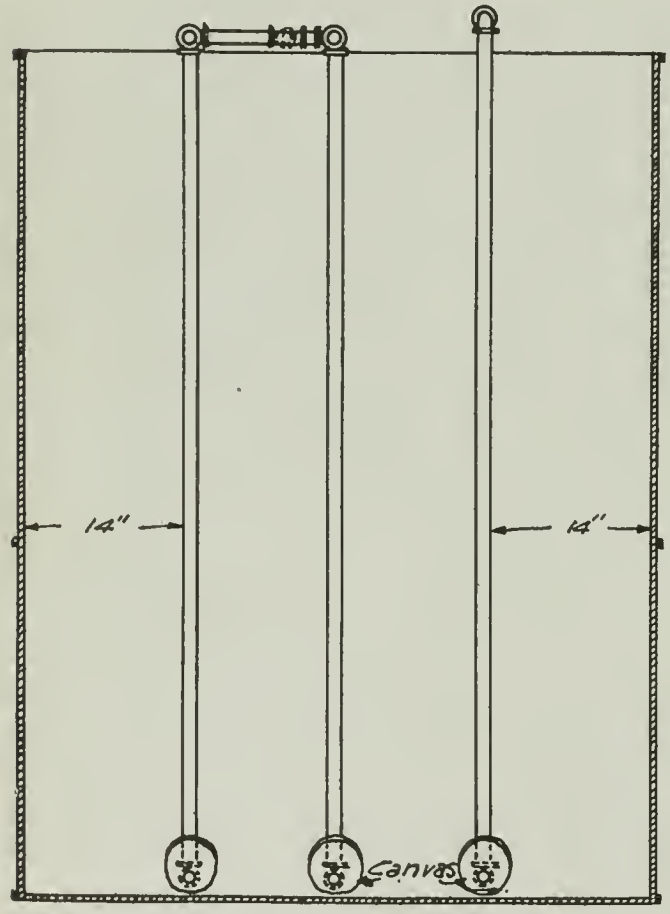
	Tank No. 1.	Tank No. 2.
February 5	4	3.9
February 12	10	3.2
February 29	5.3	...
March 2	3.3	...
March 14	1.9	2.0
March 15	5.0	2.7
April 1	...	1.7
April 17	2.6	2.6
April 18	2.8	2.8

The size of the plant has not warranted an attempt to determine the cost of operation. The idea in starting was, as set out above, to obtain data on the adaptability of the process, after which a request might be made for an appropriation to build a plant on a sufficient scale to represent the final lay-out of the plant which would be required to take care of the sewage from the entire city. The results now indicate that the process is adaptable to our local conditions, and consideration is being given to the design of a large scale unit.

The experiments were instituted by Mr. R. O. Wynne-Roberts, the city's consulting engineer, and conducted by him up to June 1st, 1915. Mr. Wynne-Roberts was assisted by Messrs. Andrews and Cruikshanks, chemists. During June and July, 1915, the work was in charge of Mr. F. McArthur, city engineer, and since August 1st, 1915, has been handled by Mr. J. Russell Ellis, acting city engineer, assisted by Mr. D. A. R. McCannel, assistant sewerage engineer.



Detail of Pipe & Canvas Cover at Bottom of Tank.



Section at C.D.

The expenditure of the Dominion Public Works Department during the fiscal year 1915-16 amounted to $19,539,298, a decrease of about ten millions compared with 1914-15.

SEWER CONSTRUCTION IN QUICKSAND.

Mr. R. H. Parsons, the city engineer of Peterborough, has been kind enough to furnish information concerning an interesting bit of sewer construction in wet sand, which he recently completed.

It was necessary to lay about 7,100 lineal feet of sewer along King, George and Park Streets, having internal diameters of 33, 30 and 24 inches with a general grade of 1 in 1,200. The two larger pipe were reinforced concrete tile pipe. The ground was nearly level and was almost entirely sand, with water at eight feet below the surface. Immediately the wet sand was excavated it became quick and required to be handled in a careful manner. The trench in the dry ground was about nine feet wide, with a rail laid on either side to carry a travelling double pile-driver. Lackawanna interlocking steel piles 12 feet long were driven into the sand on each side of the open trench, leaving about 6 feet clearance between. These were held in place as the wet sand was removed by hand, by 3-in. x 12-in. elm walings and screw-trench braces placed every 4 or 5 feet horizontally and 4 feet vertically. The dry trench was shored up by the usual type of waling and struts. The average depth of the trench was about 15 feet, consequently the quicksand had to be removed to a depth of about 8 feet.

As the quicksand would not carry any weight it was necessary to adopt a special method of sewer construction. Tamarac piles 4 to 5½ inches in diameter were driven into the sand 4 to 10 feet, and 6 feet apart longitudinally and 4 feet apart transversed. Caps 2 ins. x 10 ins. were placed on the parallel row of piles and on the caps 2-in. x 10-in. platform lumber. The platform was a few inches below the required invert level of the sewer. Rough boards were placed on either side of the trench and on these and the platform was placed 1 : 2½ : 5 concrete. The sewer pipes were cast in moulds on the surface by Messrs. Taylor and Hall and the concrete was composed of 1 : 2 : 3, reinforced with triangular mesh 4 ins. x 4 ins.—half a pound of metal to the square foot placed in position to take up tensile stresses. These pipes were 3 feet long.

The reinforced concrete pipe were carefully set on the concrete in the required position and the space between the external sides and the trench boards filled in with concrete with a splayed finish. The exposed parts of the joints were grouted with cement and covered with a layer of rich mortar.

Pile-driving was a slow work as it took as many as 150 blows of the hammer to cause the pile to sink 12 feet. Water jet and steam jet were tried to facilitate the driving but they were found of little use. The cost of labor and fuel for pile-driving amounted to an average of about 55 cents per lineal foot forward, whilst the excavation, piling, drawing piles, laying the pipes and refilling, cost about $6 per foot run. The total cost of the work, including everything, amounted to about $12.61 per foot run.

The pile-driving was done by a pair of hammers operated on a double derrick and from a compound drum. so that there was no changing from side to side. The derrick straddled the trench and ran on rails. The equipment for extracting the piles consisted of a rolled steel joist resting on a frame on each side of the trench and on the joist there was placed a 10-ton chain block which could be moved from side to side as required.

Pumping had to be carried on by means of a 3-inch centrifugal pump driven by a 10-h.p. electric motor. Power lines were attached to temporary poles set along the route.

NATIONAL INDUSTRIAL PREPAREDNESS MEMORANDUM

TEXT OF A DEVELOPMENT PLAN CALLING FOR THE FORMATION OF A PERMANENT CONSULTING BOARD—SUBMITTED TO THE GOVERNMENT VOLUNTARILY BY FIVE PROMINENT CANADIAN ENGINEERS

SIR CHARLES ROSS, M.Am.Soc.Mech.E., and head of the Ross Rifle Co.; Prof. C. H. McLeod, secretary of the Canadian Society of Civil Engineers; and R. A. Ross, Walter J. Francis and H. R. Safford, councillors of the Canadian Society of Civil Engineers, voluntarily forwarded, last April, to the Prime Minister a memorandum on industrial preparedness.

Acknowledgment of the memorandum was received, but nothing further was heard concerning it until Sir Wilfrid Laurier requested that it be tabled in the House last week, along with other communications from the Canadian Society of Civil Engineers or members thereof. Now that the document has been "brought down" publicly, *The Canadian Engineer* feels at liberty to publish it, as it will undoubtedly interest all members of the engineering profession in Canada. Following is the text of the letter of transmissal:—

"Acting on the suggestions of Sir Charles Ross and subsequent discussions, the undersigned engineers have the honor to transmit for your consideration a memorandum of their views regarding a National Industrial Development Plan for the Dominion. While we appreciate that this highly important matter has, no doubt, already received much careful consideration by the Government, nevertheless we sincerely trust that this memorandum may prove of service to you, and that you may find our suggestions acceptable. We submit them from a sense of patriotic duty and because we believe that Canada may well follow the example of the United States and other countries in calling upon engineers and scientists to render assistance, not only in these critical times, but in those which will succeed the war."

The accompanying memorandum was as follows:—

The Necessity for a National Industrial Development Plan.—The history of any community or country is a record of the cycles of dynastic, economic or industrial change, the period of change in each instance being marked by a pause in the established order of progress.

The Dominion of Canada in common with the rest of the civilized world is at this time experiencing an interruption in its course of rapid development. Her position today may be likened to that of an industrial enterprise which has been financed and made ready to operate, and which has reached the time when dividends must be earned upon the expended capital before further capital is obtainable for increasing the equipment. In such a case prudent foresight dictates the taking of stock and the organizing of the enterprises along lines which will ensure co-operation among the different departments with a view to the largest possible production.

In this country the Government, through its various activities, has taken stock to some extent of our land, forest and mineral resources, and has in a degree also interested itself in investigations of the manufacture of certain products, such as steel and paper.

The curtailment of imports and the increasing demands resulting from the present war has compelled Canada to depend upon and to develop a number of her own resources. Zinc, for example, heretofore largely produced abroad, is now being smelted in this country, and magnesite, formerly imported, is now being mined, utilized and exported in considerable quantities. Phosphates, recently discovered, may later be added to our productions.

It would therefore appear that if a concerted effort were made to determine our requirements for domestic and foreign trade and to investigate the results from an economic standpoint, the country as a whole and our industrial enterprises individually would be placed in a position to develop and increase their activities along logical lines within the limits of known resources.

A knowledge of the mere existence of raw materials is insufficient. It is essential that their character, best uses and final fabrication into marketable products should be studied. Teamwork by the business interests, led, directed and assisted by the Government, would appear to be the proper method of systematizing all our forces in order that the greatest good to the greatest number may result.

The beginning of a cycle of industrial production has arrived, and if Canada is to increase her industrial weight in the world or even maintain her relative importance and her normal rate of increase, it is imperative that concerted action be taken towards co-ordinating her efforts as other countries are doing.

The Results Desired Through a National Industrial Development Plan.—A community is an economic unit, and the mechanisms of that unit should be so co-ordinated as to produce the largest and most far-reaching results. A primitive community, fed, clothed and housed, having no further necessities is an agricultural state only. Rapid increase of population and urban concentration demand the creation and development of new mechanisms to provide food, clothing and habitations. Industrial enterprises must be created to support the population. Means of communication and transportation must also be established for the handling of either raw or manufactured products among the various groups and between the point of production and the transportation outlets of the country. There will, therefore, immediately spring up a demand for products other than bare necessities. As everything is derived from the earth, two questions arise, the first being whether or not the additional products can be obtained economically from the resources of the country, and the second whether or not these additional products may be economically turned into finished products within the country. The correct answers to these questions demand close study on the part of the most scientifically trained minds.

At the present time the industrial enterprises of the country are working individually, each towards its own end, without being mobilized for efficient production from a national standpoint. It is obvious that systematic co-operation of the various enterprises will result in benefit to the country as a whole.

We are of the opinion that information regarding the resources of the country and the results of the study of the economics of the industrial situation should be made and rendered available to the public. If this were done, present undertakings would benefit and many new enter-

prises would spring up with a reasonable prospect of success. The Government is the only organization which can properly co-ordinate, instruct and give direction to the activities of the country. If furnished with properly ascertained facts and with co-ordinated Government guidance, no industry, whether established or newly formed, can fail to benefit itself and the whole community.

To be more specific, we mention a number of points which will doubtless arise for consideration in the working out of a national development plan.

(*a*) The gathering of statistics of the products of the country as regards both quality and quantity, the conditions of production or growth, the cost of production and the cost of marketing.

(*b*) An investigation as to the possibility of the economic production of any article of commercial importance not now manufactured, mined or grown in Canada.

(*c*) The most profitable methods of manufacture or growth of present or future products, and the increase of output. This involves provision for research, trade schools, and the intimate personal training of the farming community by means of model farms and otherwise.

(*d*) Complete information regarding the most advantageous markets, a point which involves full study of the problems of transportation.

The results which should flow from this work are,—

(1) More complete utilization of the national resources of the country,

(2) The general introduction of more scientific and commercially profitable methods of production,

(3) An increase in production by reason of the improved methods and widened fields of operation, and

(4) A reduction in cost to the consumer through the elimination of unnecessary handling and improvement in transportation.

A Suggested Method of Procedure to Obtain the Necessary Information for the Establishment of a Policy.—It is a well-established fact that the material development of modern civilization is in the hands of the engineer and the chemist.

The necessity for a national industrial development plan and the results desired therefrom have been fully recognized by other nations. It is needless at the present time to refer to the fact that Germany recognized the need very early, and had long since begun to reap the results the German Government desired. The economic and military preparedness of Germany has indicated to the rest of the world not only the advisability but the absolute necessity of scientific handling of the economic resources and forces of the community.

Spurred on by recent events, Great Britain, France and the United States of America have each in its own way seriously taken up the subject,—one of the most important of the present day. The war over, competition will be unprecedented. With Europe impoverished as a result of the struggle her immediate need will be employment for the industrial population in order not only to prevent starvation in the industrial ranks, but as far as possible to regain the lost wealth and to recover the lost trade.

Although affected favorably rather than otherwise by the present situation, the United States recognizes the above facts and realizes that future competition is something which may only be met by the most thorough preparation. The Americans have therefore taken up the question of national preparedness and have appointed what is known as the Naval Consulting Board, consisting of representatives nominated by the great engineering and scientific bodies of the United States, namely,—American Society of Civil Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers, American Institute of Mining Engineers, American Chemical Society, American Electrochemical Society, American Mathematical Society, American Aeronautical Society, The Investors' Guild, The American Society of Automobile Engineers and American Society of Aeronautic Engineers.

Originally the Naval Consulting Board was intended to act in an advisory capacity with regard to naval affairs only, but its activities have since its organization been extended to include the investigation of the industrial resources of the country with a view to advising on a national policy therefor. It is interesting to note that practically the first recommendation made by this body was for the establishing of a national laboratory devoted to the solving of problems in chemistry, metallurgy, aeronautics, electricity and kindred subjects, and the placing of the information so obtained at the disposal of the community.

The recommendation for a national laboratory was made notwithstanding the fact that the Bureau of Standards of the United States, already established about fifteen years and quite broad in its field of action, has been doing excellent work and rendering valuable service to all classes of the community. In making the recommendation the Naval Consulting Board doubtless had in mind the development of equipment especially suited to the requirements of the army and the navy on such a scale as would demonstrate results before attempting commercial manufacture. By this course all new developments in guns, aeroplane engines and the like may be thoroughly tried out before the placing of large contracts by the Government.

The organization of the Naval Consulting Board has placed the scientific and technical talent of the country at the disposal of the United States without cost for professional service.

The French Republic has organized a civilian board similar to the United States Naval Consulting Board and has raised it to the dignity of a ministry (Le Ministere des Inventions). Great Britain has also enlisted the services of a board of civilian scientists and technologists with a view to the utmost development of the nation's industries for the prosecution of the war.

In view of the action of the United States, France and Great Britain, we are not suggesting a new or untried principle. This is further confirmed by the bibliography attached hereto. If engineering may be turned to the advantage of the country, we conceive it to be our duty to respectfully suggest that an invitation to co-operate be extended to the engineering and scientific societies in order that they may be in a position to render an official service to the Dominion.

The Government of the United States in appointing the Naval Consulting Board, selected engineers who have wide knowledge of engineering economics, thereby admitting that many of the problems of the industrial community are both scientific and economic in their nature. It was recognized also that the Government of the United States itself could not meet a situation of this kind through its own bureaux since they are lacking in that contact with commercial conditions which is the essence of the case. Further, no mobilization of industrial organizations could be expected from the interested business enterprises acting apart from the Government. In other words, it was recognized that between the Government

and industry there was required a body commanding the respect of both and recognized as authoritative by reason not only of its scientific attainments but also by reason of its disinterestedness. Under these conditions the Government of the United States naturally turned to the engineering and scientific societies as being the only group from which could be expected the necessary technical and economic knowledge coupled with freedom from the rivalries of the commercial world.

We are therefore encouraged to express the opinion that the Canadian Government cannot do better than address the engineering and scientific societies of Canada, inviting them to appoint from their number representatives whose advice would be at all times available to the Government. We feel sure that the engineers and scientists in Canada have as much public spirit as their professional brethren in the United States, and that a properly authorized consulting board of engineers would draw to itself the best talent in the country, and that without remuneration.

Following this idea, we venture to express the view that the necessities of the immediate present at least might be met by selecting representatives of the civil, mechanical, electrical, mining and chemical engineers.

There is in Canada one engineering organization, namely, the Canadian Society of Civil Engineers, which embraces all branches of engineering and may be taken to correspond largely to the five great scientific bodies from which the Government of the United States selected the great part of its Naval Consulting Board. There are in addition two other organizations of less magnitude and which include in their membership a number who are also members of the Canadian Society of Civil Engineers. These two are The Canadian Mining Institute and The Society of Chemical Industry. The Royal Society of Canada may also be considered a scientific society, but the great majority of its members are devoted to philosophy and literature. The accompanying chart indicates the number of fully qualified technical men in each of the organizations named.

In order that our view may be either confirmed or modified, we beg to suggest that the Government call prominent members of the industrial, engineering and scientific communities into its counsel and question them as to the necessities of the case and the best methods of procedure.

The Formation of a Permanent Consulting Board.—Assuming that the results of the investigation made along the suggested lines have been favorably considered by the Government and found acceptable in a broad way to all parties, it becomes pertinent to indicate the possible organization and power of such a body.

The introduction of a consulting board into the mechanism of government should not result in any upsetting or changing of the present Government organizations. On the contrary, the Consulting Board should be supplementary to and independent of the executive and be free to act either in the interest of any individual department of the Government or in the interest of the Government as regards its general policy in relation to industrial development.

Possibly the Government may later consider it advisable to establish a "Ministry of Industrial Development" or a "Ministry of Science," but if so this does not in any way affect the principle of the present suggestion. We have attached hereto a diagram indicating our ideas of the function of the permanent Consulting Board and its relation to the Prime Minister.

We trust we may be pardoned for suggesting that the personnel of the Permanent Consulting Board should be free from political, individual or trade bias. The members should be in a position to deal with the technical matters presented to it in the same disinterested spirit as that with which the Bench acts, and in the suggestion referred to above this feature has been carefully kept in mind.

Assuming, then, the concurrence of the engineering and the scientific bodies above referred to, we would suggest that the Consulting Board be composed of two representatives in civil engineering, two representatives in mechanical and electrical engineering, two representatives

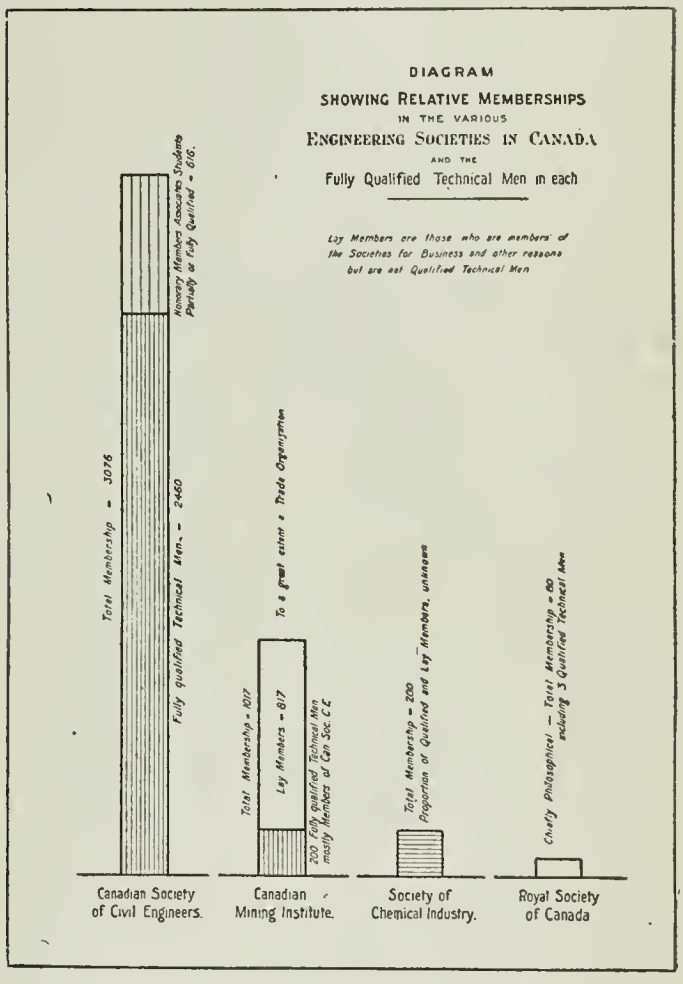


DIAGRAM
SHOWING RELATIVE MEMBERSHIPS
IN THE VARIOUS
ENGINEERING SOCIETIES IN CANADA
AND THE
Fully Qualified Technical Men in each
Lay Members are those who are members of the Societies for Business and other reasons but are not Qualified Technical Men
Total Membership = 3076
Fully qualified Technical Men = 2460
Honorary Members Associates Students Partially or Fully Qualified = 616.
Total Membership = 1017
Lay Members = 817
200 Fully qualified Technical Men mostly Members of Can Soc C E
To a great extent + Trade Organization
Total Membership = 200
Proportion of Qualified and Lay Members unknown
Chiefly Philosophical — Total Membership = 60 including 3 Qualified Technical Men
Canadian Society of Civil Engineers.
Canadian Mining Institute.
Society of Chemical Industry.
Royal Society of Canada

in mining and metallurgical engineering, and two representatives in chemical engineering, all nominated by their respective societies to act each during the pleasure of the Government or of the nominating bodies. Further, we would suggest that the recall of any member be at the option of either the Government or the Society, replacement, however, to be always at the discretion of the Society.

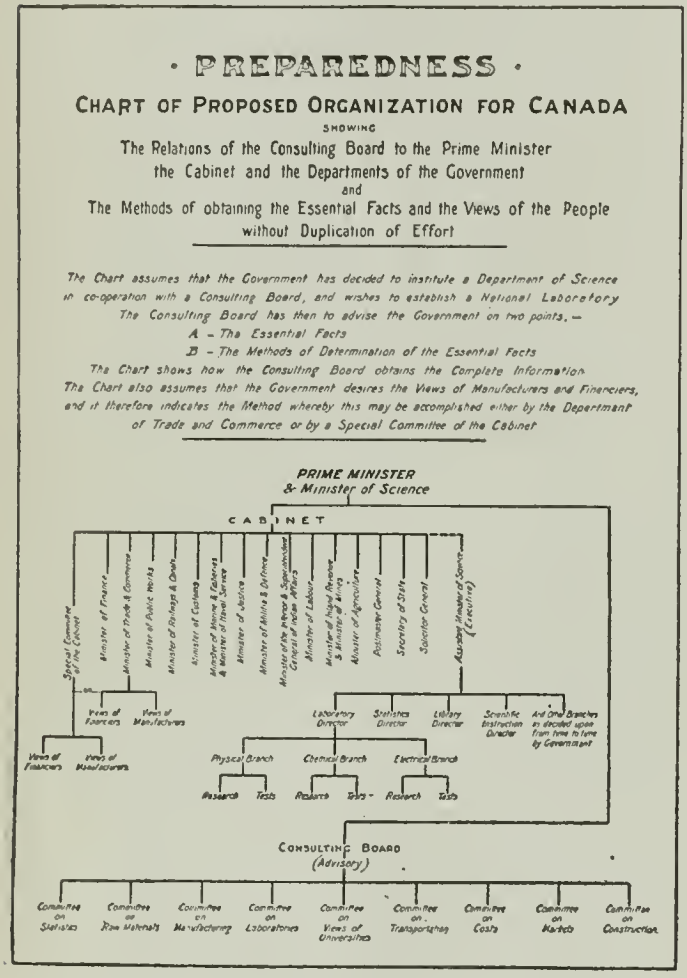
The official headquarters would presumably be at Ottawa in an office provided by the Government, together with a well-paid and highly competent engineering secretary.

The operations of the Board will require a certain amount of detail work, usually performed by subordinates. We believe that the Consulting Board should be authorized to appoint the necessary subordinates to carry out details.

If it be found desirable to make a census or investigation of the industries of the country the Board might

call upon non-paid technical assistants from the branches of the societies in the different Provinces, following the course pursued by the Naval Consulting Board of the United States in investigating the industrial resources of each State.

Function of the Consulting Board.—The function of the Consulting Board is outlined in the diagram already referred to. Briefly, it should act as consulting engineers


· PREPAREDNESS ·
CHART OF PROPOSED ORGANIZATION FOR CANADA
SHOWING
The Relations of the Consulting Board to the Prime Minister the Cabinet and the Departments of the Government
and
The Methods of obtaining the Essential Facts and the Views of the People without Duplication of Effort
The Chart assumes that the Government has decided to institute a Department of Science in co-operation with a Consulting Board, and wishes to establish a National Laboratory
The Consulting Board has then to advise the Government on two points, —
A – The Essential Facts
B – The Methods of Determination of the Essential Facts
The Chart shows how the Consulting Board obtains the Complete Information
The Chart also assumes that the Government desires the Views of Manufacturers and Financiers, and it therefore indicates the Method whereby this may be accomplished either by the Department of Trade and Commerce or by a Special Committee of the Cabinet
PRIME MINISTER
& Minister of Science
CABINET
Views of Financiers
Views of Manufacturers
Laboratory Director
Statistics Director
Library Director
Scientific Instruction Director
Physical Branch
Chemical Branch
Electrical Branch
Research
Tests
CONSULTING BOARD
(Advisory)
Committee on Statistics
Committee on Raw Materials
Committee on Manufacturing
Committee on Laboratories
Committee on Views of Universities
Committee on Transportation
Committee on Costs
Committee on Markets
Committee on Construction

to the Dominion Government represented by the Prime Minister, independent of any department of the Government yet available through the Prime Minister to all, in precisely the same way that the general manager of a large corporation has consulting engineers at his call, not on his staff but available to take up, independently of the working organization, all such technical or economic problems as he may desire to have solved.

The Creation and Maintenance of a Department of Investigation, Research or Reference.—If the Consulting Board be constituted along the lines we have suggested it will probably recommend that the Government establish a national testing and investigating laboratory for technical tests, investigation, research, reference or experiment. Such a laboratory would do for the Government precisely what any laboratory department does for a large manufacturing company,—namely, investigate the materials supplies, the processes employed in producing finished products and the economics of the production as related to technical matters.

[NOTE:—The above memorandum was accompanied by an exhaustive and valuable bibliography.—EDITOR.]

ACCURACY OF STREAM FLOW RECORDS.

By K. H. Smith, A.M.Can.Soc.C.E.
Resident Engineer, Dominion Water Power Branch, Halifax.

DURING the course of his regular work the writer found it necessary to compile stream flow records of a number of streams in Nova Scotia for which a limited number of measurements were available upon which to base rating tables. When additional measurements were obtained, these records were revised and in several cases the additional measurements were sufficient to establish fairly satisfactory rating curves.

An attempt has been made in the accompanying table to show the preliminary and revised records in such a way that they may readily be compared. It is believed that these results are of interest to those engaged in hydrometric work and particularly to engineers who are obliged to make preliminary estimates of water supply in districts where stream flow records for a reasonable length of time are not available. In fact, it is thought possible that more satisfactory results may be obtained from approximate rating curves and gauge heights for limited periods than from studies of rainfall alone. In most cases evidences of high-water mark may readily be found and referred to the gauge height, while frequently, as well, evidence of average low water may be secured, which average for cases where storage is contemplated is more useful than a record of an individual minimum flow.

It is obviously impossible to present in tabular form all the conditions affecting the accuracy of the results obtained. The number of measurements are given in each case and their range, though the accuracy of the results depends not only on the number and total range of the measurements, but also on their distribution. The general conditions at the gauging station, such as average velocity, nature of the channel, banks and control are also contributing factors. For more complete information in regard to each of the stations listed, the reader is referred to a report of the Nova Scotia Water Power Commission to be issued shortly. It may be assumed, however, that fairly good conditions obtain at each of the stations given.

It should be noted that possibly part of the differences obtained in the revised records may be due merely to revision rather than to additional available data. Moreover, in the case of small streams such as Archibald Brook and Fall River, the difference between the preliminary and revised records, when expressed as a percentage of flow, is somewhat out of proportion to the importance of the actual difference.

It is, of course, to be understood that carefully determined cross-sections were obtained at each station and that these sections extending above high-water mark are considered essential in defining approximate rating curves. Various methods for extending rating curves are discussed by Messrs. Hoyt and Grover in their book on "River Discharge" and need not be mentioned here. However, the writer wishes merely to state that for his own work, he has obtained the most satisfactory results from plotting on ordinary cross-section paper the measured discharge as a function of $A\sqrt{d}$. Where A is the area of the section and d is the mean depth. This is one of the methods described in "River Discharge." In the case of the St. Croix River, one of those listed herewith, a measured discharge of 1,064 second-feet was obtained at

a gauge height for-which 1,010 second-feet had been computed by the method indicated from seven previous measurements, the largest of which gave only 174 second-feet. That is, the difference between the computed and measured discharge was only 5 per cent. of the measured discharge, the maximum error generally assumed for individual current meter measurements.

While it is intended primarily merely to present this data as representing actual results obtained, several points might be noted:

(1) The average flow obtained from the preliminary records is in every case within a very small percentage of the revised results. This is true even in the case of Fall River, where only two measurements were available for the preliminary computations.

(2) The records of minimum flow as obtainable in the preliminary computations are generally more largely in error than the records of maximum flow. Naturally, irregularities of the stream bed have greater effect on the distribution and direction of the current at periods of low flow. However, the revised records of minimum flow are in most cases more accurate than the revised estimates of maximum flow, and the errors of the preliminary records of maximum flow may ultimately be slightly greater than they appear at present.

(3) In general, the preliminary computations of maximum flow for the period are within a small percentage of the revised results. Greater differences may develop when further measurements for higher water stages are secured, though high-water measurements already obtained and used in obtaining the revised results, as for example, in the case of the St. Croix River seem to indicate a comparatively small error in the preliminary computations.

(4) After a reasonable number of well-distributed measurements have been obtained at a station where permanent conditions obtain, the increase in accuracy for additional measurements is small. For example, 10 measurements on the Indian River gave results identical with the results obtained for 13 measurements, except in the case of the minimum flow, where there is a small difference.

Table Showing Comparative Results for Computations of Flow of Certain Streams in Nova Scotia.

River.	Basis of Preliminary Records.	Basis of Revised Records.	Period in Days.	Preliminary Records. Max. Sec.-ft.	Min. Sec.-ft.	Mean Sec.-ft.	Revised Records. Max. Sec.-ft.	Min. Sec.-ft.	Mean Sec.-ft.	Differences. Percent. of Revised Records Max.	Min.	Mean.
Archib'd Brook	5 measurements, 47 sec.-feet to 135 sec.-ft.	9 measurements, 3.4 sec.-feet to 135 sec.-ft.	152	707	8	75	560	7	72	26	14	4
Fall River ...	2 measurements, 64 sec.-ft. and 93 sec.-ft.	6 measurements, from 1 sec.-ft. to 93 sec.-ft.	121	135	14	60	135	10	58	0	40	3
Gaspereau ..	9 measurements, 55 sec.-feet to 375 sec.-ft.	12 measurements, 26 sec.-feet to 1,536 sec.-ft.	317	3,396	46	385	2,975	41	382	14	12	0.8
Indian	10 measurements, 77 sec.-feet to 1,597 sec.-ft.	13 measurements, 5 sec.-feet to 1,597 sec.-ft.	327	1,597	47	173	1,597	45	173	0	4.4	0
Lahave	4 measurements, 184 sec.-feet to 2,982 sec.-ft.	5 measurements, 184 sec.-feet to 2,982 sec.-ft.	202	4,313	197	1,134	4,388	184	1,125	1.7	7	0.8
Medway	3 measurements, 246 sec.-feet to 3,084 sec.-ft.	4 measurements, 246 sec.-feet to 3,084 sec.-ft.	226	3,232	186	1,473	3,232	176	1,426	0	5.7	3.3
Northeast ..	9 measurements, 33 sec.-feet to 382 sec.-ft.	13 measurements, 17 sec.-feet to 382 sec.-ft.	327	391	18	89	387	21	90	1	14.3	1.1
Philip	5 measurements, 134 sec.-feet to 531 sec.-ft.	6 measurements, 58 sec.-feet to 531 sec.-ft.	273	3,694	72	316	3,780	56	308	2.3	29	2.6
St. Croix	7 measurements, 61 sec.-feet to 174 sec.-ft.	10 measurements, 6 sec.-feet to 1,065 sec.-ft.	316	1,010	20	206	1,064	33	205	5	40	0.5
St. Marys ...	5 measurements, 412 sec.-feet to 4,370 sec.-ft.	9 measurements, 49 sec.-feet to 4,370 sec.-ft.	245	13,800	219	1,405	13,730	116	1,352	0.05	89	4

USE OF GAS AT THE FRONT.*

By W. B. Campbell.

THE Germans first used gas a year ago last spring. There was a feeling of horror, but there was also the impression that the Germans were very ingenious people to bring out this scheme. They are not!

If you read the Sunday papers, and I guess most everyone reads them at times, you will notice that it is quite a common habit for the writers to concoct wild stories of all kinds of inventions, especially inventions for killing people in warfare. The first mention that was made in those papers of the "tanks" showed a machine about 200 feet high. Well, the Germans' use of gas was somewhat along the line of these stories. It is not a new idea at all.

Perhaps the first time gas was actually used was the "stink bombs" of the Chinese. They were not poisonous but were intended to annoy the enemy as a cover for something more effective.

A popular story is that a great secret is locked up in the Tower of London, which, if the British government would only consent to use it, would wipe out all enemies wherever they are, but that the government is too humane to do that! The basis of that story, and it has a basis, is that about seventy years ago the use of chlorine as a weapon of warfare was actually proposed. It was Lord Dundonald, I think, who suggested it at that time, and the suggestion was turned down. The fact that gas could be used was quite well known. It was sufficiently well known to be taken up at one of the Hague conferences and they decided against it. However, the Germans did not mind that,—merely a scrap of paper.

As gas is used at the front to-day there are two forms of it, liable to confuse people when reading the newspapers. There is what is known as cloud gas, the poisonous kind, sent up in cylinders and released and sent across in the form of a cloud. Then there is what is known as shell gas, which is sent across in shells and released on the breaking of those shells. The cloud gas is the most important and the most deadly. It may seem a fairly convenient weapon, but if you will consider the gases that it is possible to use and the properties necessary to make them usable at all, you will see that it is not such an easy thing. First, as to the properties; the gas must be heavy; it must be at least twice as heavy as air. If not, it will diffuse too readily and be thinned out by the time it gets to the enemy trenches and be of very little use. The gas must be compressible to a liquid, so as to be transported, in cylinders, in bulk. It must not be a liquid of such a high boiling point that it will boil off with rapidity. It must be poisonous,—the more so the better.

Some of the gases ordinarily considered poisonous are not nearly poisonous enough to be used in this way. The arsine, $As\ H_3$, that compound of hydrogen and arsenic, which has a specific gravity of 2.7. This makes it plenty heavy enough. It can be liquefied. It has a convenient boiling point, but at 1/10 of 1% it takes about two hours exposure to kill. Then there is sulphur dioxide. That is more poisonous than most people think. It has a fairly convenient specific gravity; its boiling point is 10 degrees below zero Centigrade. In comparing the toxicity of these gases there are two terms used—the minimum effective concentration, that is the least concentration which will kill a man or knock him out in five minutes, and the maximum bearable concentration, that is the most that can be stood without danger for one hour. Sulphur dioxide has a minimum effective concentration of .05%, so it is a rather poisonous gas.

Some of the other gases that might be thought of are nitric oxide, boiling point of 26 deg. Cent., fairly heavy, and about as poisonous as sulphur dioxide. The high boiling point stops its use as cloud gas and it is not sufficiently poisonous to make it useful for shell gas.

Another one is hydrogen sulphide. That has a low boiling point but it is a little bit too light to use as a cloud gas, and it is only about half as poisonous as sulphide dioxide.

To come down to the ones really effective, first there is chlorine. That is the one the Germans used in the first gas attack. It has a boiling point of 36 deg. below zero Cent. It is two and a half times as heavy as air. It is very convenient. It can be liquefied and put into cylinders. It boils off rapidly and its minimum effective concentration is .01%, five times as poisonous as sulphur dioxide. The maximum concentration is about half of that.

Prussic acid is only three times as poisonous as chlorine. Another gas the Germans are making considerable use of is phosegene. That is not an ideal gas. It is twice as poisonous as chlorine, but it takes twice as long to kill. Another thing against it is that it has a boiling point of 8 degrees Cent. That is higher than the temperature you encounter on a fairly cold day in winter weather over there. There are a good many days when that gas would not come out of the cylinder at all. It is used mixed with chlorine. It is effective because it has serious after-effects on a man's heart. A man will get a small amount of it into his system, so small an amount that he will not think he has been gassed at all, but maybe two or three hours later he will be filling sand bags or doing some other work around the trenches and his heart will go back on him and he will drop exhausted or dead. The first time this gas was used the after-effects on the heart were not looked for and there was one party of men who had been slightly gassed but their officers did not consider them badly affected. They were sent to march out to the dressing station. None of them reached the dressing station. Now men have instructions that after being exposed to gas, they are not to move out of the trenches or do any more work than absolutely necessary for twenty-four hours. During that time the effect of the gas will wear off.

As to the quantity used, this is rather surprising. The effective concentration of chlorine is .01%, one part in ten thousand. Of course it is necessary in calculating the concentration for an attack to prepare to use more than that amount. Say you are figuring on using ten times that amount (the Germans in one attack sent over gas strong enough so that the men had to use helmets ten miles back of the line), that is, a concentration of 1/10 of 1%, a wind of ten miles per hour (that is just a moderate breeze) and a cloud eight feet high at the enemy's trenches, if you figure that out you will get about 22,000 cubic feet of air passing over each yard of trench per minute, and this must be loaded up with chlorine. That requires about 22 cubic feet of chlorine, or 4¼ pounds, per minute per yard of trench. That does not sound much, but when you figure it by the mile, the way gas attacks are made, it mounts up.

*Paper read before the Canadian Society of Civil Engineers, Montreal, January 11, 1917.

An attack for fifteen minutes means fifty tons of chlorine per mile of front. Chlorine is taken up to the trenches in cylinders each containing sixty-five pounds of the liquid. The cast-iron cylinder weighs roughly about 65 pounds more; that means one hundred tons of material to be carried up to the trenches to make an attack of fifteen minutes. The cylinders are clumsy things; they must be carried up at night so that the enemy cannot see them; they must be brought up along a communication trench probably half a mile long with a crook in it at every ten yards or so, and one of those cylinders are required to every yard of trench. It takes four men to a cylinder; two men carrying and two to relieve them every hundred yards or so.

The only preparation for an attack of this kind on our front was intended to cover a small raid. When this gas was to be brought up, the command was given that in carrying these cylinders nobody was to mention the word gas or cylinders, because sound travels pretty well and the trenches are not very far apart. You can imagine the delights of lugging around cylinders weighing about 130 pounds, and all done in the dark. Before that, we were all anxious to make a gas attack, but this experience cured all such desire.

Besides carrying up these cylinders there were other preliminary preparations. The cylinders were to be placed in the ground. We had to set boxes each holding four cylinders. That is so that the gas would be well protected from shell fire. That was all done a long time ahead. As a matter of fact, now practically the whole line from one end to the other is equipped with boxes in the fire step so that gas can be brought up and delivered from any point on short notice. Well, supposing you have made that preparation, you have arranged with the divisions on either side to have a smoke attack for perhaps two or three miles, the artillery has its orders and everything is to break out on a certain signal, about one o'clock in the morning. One o'clock in the morning comes and the the wind dies or turns around another way, and the affair is called off for another night, when the same thing happens again, and after about a week of that sort of performance, the objective of that raid is no longer there, or probably the Germans know you have gas and you lug the cylinders out again.

Then, the gas shells are another proposition. I do not know whether the Allies are using gas shells or not. They were not when I left last summer, but they may have started since. These are not very effective. The Germans used two kinds. The most effective are what are known as tear shells. They contain a gas which is not poisonous in the quantities used, but it irritates the eyes and gives the same feeling as would peeling onions. Protection against this is afforded by means of goggles which exclude all the air, and that is plenty of protection. If the gas is very strong the irritation may be sufficient to affect the nose and throat and even cause vomiting. It is not poisonous, however, and the effects are only temporary. As soon as one gets to fresh air the trouble is all gone. The other kind of shells used by the Germans are poisonous. They have very much the same effect as phosegene. The poisonous effect of these shells is not very great, though, because it is difficult to get sufficient concentration. When one of those shells breaks they have to follow it with another shell pretty quickly to get any effect, so, though the Germans used those quite plentifully around our trenches, nobody was gassed.

When the gas was first used at Ypres in April, 1915, our men had no protection whatever against it. They did not get the worst of it at that time, but the French troops were completely cleaned out on two miles of front. Evidently the German general staff had no idea how effective the gas was going to be because they made no preparation to follow it up the way they might have done. Immediately after that attack protection began to be devised. The women of England made over a million respirators, of a kind, in three days on an appeal from Lord Kitchener. They were crude, of course; simply a small pad stuffed with cotton, with a piece of elastic to hold it over the mouth. This was supposed to protect the mouth and nose. The pad was soaked in a solution of sodium carbonate, but it was difficult to breathe through. Immediately following those was a type which covered the nose better. It was soaked in a solution of hypo and sodium carbonate, and if carefully put on was quite effective against chlorine. Shortly after that the first helmet type of respirator was produced. It was simply a bag of flannel with a similar solution plus glycerine. It was not a good respirator in many ways. The men breathed in and out in a small space all the time and the doctors said they would smother. But that was not the case. They got enough fresh air but it was not very comfortable. That combination of chemicals is perfectly good against chlorine.

But about July, 1915, word was brought that the Germans were preparing phosegene to be used against us, so some protection had to be devised. A new respirator was brought out which was an improvement on the former one. The chemicals used on the pad were costic soda and carbolic acid. It was effective against chlorine and to some extent against phosegene. The helmet was much more comfortable than the other, but the protection was far from perfect. It would not protect against the amount of phosegene that could be used in summer weather, but it was the best that could be had at that time. However, the Germans did not use the phosegene until December, 1915. It was rather cold and these helmets furnished perfect protection against the amount used at that attack. Something better was being worked on all the time that this helmet was being used, and last spring a helmet was issued that was protection against phosegene and a whole assortment of gases. It had one defect, namely, that it generated a certain amount of formaldehyde which was very irritating on the eyes, so much so that men were likely to get the idea that they were being gassed when they were not, so that they would take off their helmets and try to put on others, many casualties then occurring. However, the men were warned against this.

Later on, a helmet with rubber sponge goggles was brought out. This was designed to protect the eyes against this formaldehyde, also to protect them from the gas from tear shells. These helmets look very heavy but the men soon get to feel quite at home in them. I have some helmets used by the Germans, and the chemicals used in one are charcoal and potassium carbonate. The chemical protection is perfectly good but there are a lot of other faults in their respirator. The weight of the box drags the helmet down and it does not fit properly, so the gas gets into the man's nose and mouth. There are other helmets made by the Germans which I have examined, but they all have some defects, and on the whole we have better protection against gas than the Germans have. Since last June the British have worked up this feature of warfare so perfectly that now we are making more gas attacks and better ones than the Germans are making, and I think the Germans are very sorry they ever started the use of gas.

REPORT OF SUB-COMMITTEE D, AMERICAN WOOD-PRESERVERS' ASSOCIATION.

The following abstracts are taken from the report of the above committee, which was submitted at the annual meeting of the association held in New York January 23-25, inclusive.

A number of sub-committees were appointed to work under the main committee. Sub-committee D was instructed to present all information available concerning the use of water-gas tar and oil for treating paving blocks, and, if in their judgment it is warranted, a tentative specification for such oil.

This sub-committee reported in part as follows:—

It was found upon investigation that there are in existence many thousands of square yards of wood-paving that, judging from the chemical analysis of the original oil now in the blocks, had been originally treated either wholly or in greater part with water-gas tar. In view, however, of the specifications and other conditions connected with the treatment and laying of many of these blocks, it did not seem advisable to include them in this report.

We have, however, submitted for your consideration the location, yardage, character of treatment, oil used, present condition, traffic conditions, and in some cases a photograph of a considerable number of streets that are paved with wood blocks that were treated with refined water-gas tar.

With the exception of two cases which are noted, your sub-committee by its personal knowledge is assured that the oil used was refined water-gas tar of the grade represented by the analysis and that the quantity injected per cubic foot was found from the block manufacturers' records to agree with the specifications.

In passing judgment on the serviceability of a material for use in treating paving blocks, your sub-committee feels that there are four features to be considered: (1) Waterproofing value of the material; (2) its preservative value as against decay; (3) permanency of the oil in the blocks; (4) ease and completeness of penetration; (5) its freedom from bleeding.

The waterproofing value of water-gas tar has been quite generally recognized.

As regards the preservative value of the material against decay, your sub-committee would report that it was unable to find any instance of decay in any of the blocks inspected by it, nor was any such decay reported from any of the uninspected work. Since a number of these streets have been in service for over eight years, your sub-committee feels justified in assuming that this feature of the requirements of a proper preservative has been amply fulfilled.

With regard to bleeding, your sub-committee would call particular attention to the fact that, from its inspections, and from the inquiries it made of those having the pavements in charge, there was an entire absence of any complaint from bleeding, not only as to the older pavements, but also on those of very recent construction.

Your sub-committee is convinced, therefore, that as a result of the fulfilment of the foregoing requirements, and in view of the uniformly successful results that were obtained, as evidenced by the examples cited in this report, the refined water-gas tar has demonstrated its value and usefulness as a preservative for wood-paving block.

It therefore recommends to the committee that refined water-gas tar be recognized as a suitable and satisfactory wood-block preservative, and that the following specifications be submitted to the association for adoption, as a standard specification for this class of material:

Refined Water-Gas Tar for Paving Blocks.—The preservative shall be a refined water-gas tar. It shall comply with the following requirements:

1. It shall contain not more than 3% of water.

2. It shall contain not more than 2% of matter insoluble in benzol and chloroform.

3. The specific gravity of the preservative at 38°/15.5° C. shall not be less than 1.110, nor more than 1.140.

4. The distillates, based on water-free oil, shall be within the following limits: Up to 210° C., not more than 5%; up to 235° C., not more than 15%; up to 315° C., not more than 40%; up to 355° C., not less than 25%.

5. The specific gravity of the total distillate below 355° C. shall not be less than 0.99, nor more than 1.02 at 38°/15.5° C.

6. The foregoing tests shall be made in accordance with the standard methods of the American Wood-Preservers' Association.

REGINA BRANCH OF CANADIAN SOCIETY OF CIVIL ENGINEERS TO WIDEN ITS SCOPE.

The members of the Canadian Society of Civil Engineers resident in Saskatchewan have unanimously decided to extend the scope of the Regina branch of the society so as to include all members of the engineering profession in Saskatchewan and have decided to change the name of the Regina branch to that of Saskatchewan branch.

A meeting for organization was recently held at Regina when the following gentlemen were elected: Chairman, L. A. Thornton, Regina; secretary pro tem, J. N. De Stein, Regina. A nominating and organization committee of five were also elected, composed as follows: L. A. Thornton and H. S. Carpenter, of Regina; G. D. Mackie, of Moosejaw; C. J. Yorath, of Saskatoon, and R. W. Ross, of Melville. This committee will convene in the near future when further organization and the general policy of the branch will be decided upon after sanction of the council of the parent society has been obtained.

A despatch from London, England, states that application will be made to the Treasury for permission to raise capital necessary to complete the irrigation of 500,000 acres of land in the Medicine Hat, Alberta, district, owned by the Southern Alberta Land Company, Canadian Wheatlands, Limited, and the Alberta Land Company. Sir William Plender is receiver for the Southern Alberta Land Company, and among others assisting in the new effort are mentioned Sir Frank Grist, Sir Robert Nivison and A. J. McMillan, who spent several months in Ottawa last summer negotiating with the Canadian Government respecting these interests. The development of land in this territory involves an expensive irrigation scheme requiring a large amount of capital. Over $5,000,000 has already been spent in construction operations, but the war prevented the raising of additional money to complete the irrigation canal system. Since the outbreak of the war efforts have been made to have the Government take over the project or to interest the Canadian Pacific Railway in the scheme in the hope that the big transportation company might go forward with the work along the same lines as its own project in the same part of the country. However, with the recent improvement in the financial situation, it is evident that an effort will be made to secure capital in England, and the present plan is to raise an additional £1,000,000 if the consent of the Treasury can be secured.

CANADA'S RAILWAY PROBLEM AND ITS SOLUTION.

By William Francis Tye, C.E.,
Formerly Chief Engineer, Canadian Pacific Railway Co.

(Continued from last week's issue.)

Before it is possible to arrive at the cure, one must understand what are the reasons which have caused the trouble.

Canada may be compared with the Siamese Twins,—two bodies, the east and the west, commercially united by a narrow ligature—the railways. The long stretch of country extending from about Sudbury to near Winnipeg, a distance of nearly 1,000 miles, is practically barren as far as local traffic is concerned, and a big drag on the earnings. Each of the two bodies—the east and the west—is very large in size, and, as yet, sparsely settled. So the railways in each body have a somewhat thin traffic local to that body, and in addition, the transcontinental lines have a through traffic from one to the other, which must be carried across nearly 1,000 miles of practically unproductive territory.

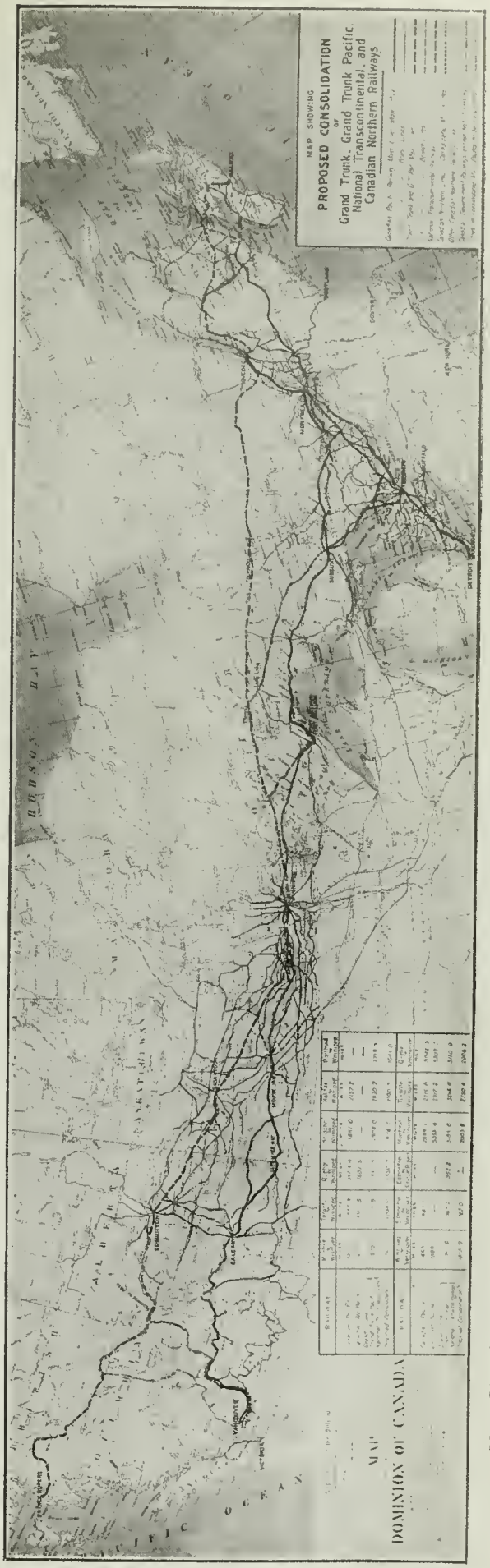
It is thus necessary that any railway connecting the two bodies have an extensive system in each, not only in order to get its fair share of the traffic, in each of the two bodies, but also to gather traffic in one to carry to the other, to enable it to pay the cost of operation on the long unproductive stretch through Northern Ontario.

The Grand Trunk, which is entirely local to the east, has always been moderately successful. It has been expensively constructed and financed. It has been controlled from London, a point too far away for effective control. It has had no opportunity to take part in Canada's greatest development which has gone on in the west, and has, therefore, been only moderately successful.

The Grand Trunk Pacific and the Transcontinental, which really form one system, have been built without any regard to the principles which underlie the economics of railway location and construction. The first essential for any railway is that it get traffic, as without traffic it cannot live, no matter how cheaply or inexpensively it be built, and this cannot be had without an extensive system of feeders. These two roads spent large sums in building main lines far in advance of their present requirements, and very little on feeders or branch lines. The result is 3,550 miles of very expensive main lines, and only 1,200 miles of branch line feeders—fixed charges equal to gross earnings, and a cost on each road of about $200 to do $100 worth of business.

The Canadian Northern was built, first as a western road, and while it remained a purely western road, was very successful, but it, too, caught the mania for a through transcontinental railway. It, too, built a long, expensive line across the unproductive country between Montreal, Toronto and Winnipeg, without, at the same time, building an adequate system of feeders and terminals in the east with which to gather traffic for the west, and to support the long, unproductive mileage in Northern Ontario.

The Canadian Pacific, on the contrary, was developed along the proper lines. It built its main line as cheaply as possible, used the funds which it saved by this class of construction rather than the expensive construction indulged in by the Transcontinental and Grand Trunk Pacific Railways, in building a system of feeders in the west and in the east. In this way it had the maximum of traffic and the minimum of fixed charges, instead of the



Map Showing Proposed Consolidation of Grand Trunk, Grand Trunk Pacific, National Transcontinental and Canadian Northern Railways.

minimum of traffic and the maximum of fixed charges, as the Transcontinental and Grand Trunk Pacific have.

As traffic developed and conditions warranted, the Canadian Pacific Railway improved its lines, thereby making a double saving of: first, the interest on the excessive first cost during the many years of meagre traffic, and, second, the very much lesser cost of doing work on a constructed line rather than in a wilderness many miles from a railway or other transportation.

The Intercolonial's troubles have been those inherent in all government management—excessive cost of construction, expensive management, and low freight rates. * * * * *

Suggested Remedies.—To remedy these matters many different suggestions have been made. These may be summarized as follows:—

1st. Transferring the Canadian Northern, Grand Trunk Pacific and Transcontinental to the Canadian Pacific.

2nd. Government ownership of some, or all, of these railways.

3rd. Aiding the Canadian Northern and Grand Trunk Pacific Railways until such time as they become profitable.

4th. The remedy which the writer advocates, consolidation of the Grand Trunk, Grand Trunk Pacific, Transcontinental and Canadian Northern in one system, under a new company to be formed.

The first of these, *viz.*, disposing of the Canadian Northern, Grand Trunk Pacific and Transcontinental to the Canadian Pacific, might be an ultimate financial success, provided that company were willing to assume the risk, but it is open to the fatal objection that it would entirely do away with all competition, which is absolutely necessary in any business. This remedy may, therefore, be dismissed without further discussion.

Government Ownership.—It does not seem possible that any one who has given serious thought to the matter can be in favor of government ownership of such an extensive system, more especially in a country so dominated by politics as is Canada. One can easily imagine what the result would be: before the first election a cry would go up for lower rates, which the politicians to suit their needs would grant. This would result in deficits such as have been so common on the Intercolonial. These deficits and the fixed charges would have to be met by taxation. The Canadian Pacific would have to meet the government rates, which would surely result in the bankruptcy of that road, or its being taken over by the government.

If all the roads were nationalized the cost would be far too much for the country to finance. There would be an entire lack of competition, which is disastrous to any business. There would be a lack of continuous management, as each party as it attained power would want to reward its own politicians by giving them the best positions on the railways, and the best men would not be selected.

The large army of government appointees necessary to run such a great mileage would be a grave danger to the purity of our elections.

The writer knows of no system of government-owned railways that has been really successful. The German railways have been apparently the most successful. But their success has been much more apparent than real, as they have been run not as a commercial, but as a huge military machine. Before the war many hundreds of miles of double track roads were in existence, with insufficient business for a single track. Money was supplied, without stint, to keep them in first-class military shape, all of which gave them an appearance of prosperity and good management, while, in reality, they were not so economically managed as the English roads.

Government Management in Canada.—Our experience of government-managed railways in Canada has not been such as to justify us in such a gigantic addition to our public responsibilities. We have now five government-owned roads in Canada, and not one of them has earned interest on its cost, and only one (the Temiskaming & Northern Ontario Railway) has earned its operating expenses. * * *

A short examination of the Transcontinental and the Intercolonial Railways is illuminating.

Construction of the Transcontinental.—The Transcontinental was built by a commission without experience in the construction or operation of railways.

The Stanton-Gutelius Commission appointed to investigate its construction, shows that its cost to 1914, exclusive of any rolling stock, amounted to $99,500 per mile. At the same time this road was being constructed, the Canadian Northern Railway Company built a parallel road for exactly the same purpose, *viz.*, to connect the eastern and western systems. The road is in every respect as efficient an instrument of transportation as is the Transcontinental, and its cost certainly did not exceed $50,000 per mile.

The Quebec bridge is a link in the Transcontinental System. With the necessary approaches it has cost $40,000,000 and was decided on and built without any consideration as to its economic value.

Train ferries, which could have been built for a small fraction of its cost, would have served every purpose for many years to come, and would have taken the traffic directly through Quebec, much to that city's advantage. Until a few years ago similar ferries handled all the traffic from the west into New York, and all the traffic across the Detroit and St. Clair Rivers. They are to-day handling all the traffic into San Francisco except that from the south.

It is quite safe to say if the Transcontinental Railway, including the crossing of the St. Lawrence River, had been built by the Canadian Pacific Railway Company, its cost would have been at least $100,000,000 less than as built by the Dominion Government.

(To be continued.)

TORONTO BRANCH, CAN. SOC. C. E.

The Toronto branch of the Canadian Society of Civil Engineers will hold its regular monthly meeting in the Chemistry and Mining Building of the University of Toronto, on Tuesday, February 13th, at 8 p.m. Dr. A. P. Coleman will deliver a lecture on "Labrador Revisited." Dr. Coleman has made two trips to the wilds of Labrador and has secured many beautiful slides. As this meeting will be of general interest, the executive of the branch extends a cordial invitation to the members to bring their lady friends.

The membership lists of the Toronto branch are being revised and the secretary will be pleased to hear from any member of the Canadian Society of Civil Engineers residing in Toronto who has not been getting notices of the branch meetings.

Editorial

INDUSTRIAL PREPAREDNESS MEMORANDUM.

The memorandum on National Industrial Preparedness, which is printed on another page of this issue, evidently reflects much thought and labor. In solving the big problems that Canada must face after the war, the co-operation of the country's engineers will be urgently needed. The voluntary efforts of these five engineers in attempting to pave the way for the solution of some of the problems, should be emulated by more members of the profession.

WATER POWERS OF MANITOBA, ALBERTA AND SASKATCHEWAN.

The Commission of Conservation has just published a 334-page report on the water powers of Manitoba, Saskatchewan and Alberta. It is a compendium of all available data respecting this great natural resource and will form a valuable book of reference. To complete the information, Mr. Leo Denis, hydro-electric engineer to the Commission, made reconnaisance surveys in the less settled portions of Manitoba, Saskatchewan and Alberta. In southern Manitoba, the Commission, following its announced policy of avoiding duplication of effort, requested Mr. J. B. Challies, superintendent of the Water Power Branch, Department of the Interior, to contribute chapters regarding this portion of the area covered. Mr. Challies, whose name appears as joint author, also contributed the chapter on the Bow River above Calgary.

Incorporated in the report are also all available data procurable from reports by the Irrigation Branch, the Geological Survey of Canada and the United States Geological Survey.

Mr. Denis has added a considerable amount of new material (having examined personally the waters to the east of Lake Winnipeg, and the Nelson, Hayes, Upper Churchill, Athabaska, Peace and other rivers), and, what is perhaps more important, has correlated the whole information in such manner that it can be used for reference readily, the information being given in very condensed form. The facts are set forth in uniform style for every stream, in each case beginning with the head waters and drainage areas and giving the data regarding the various power sites in the order in which they occur, following the river down stream.

This style is similar to that followed in the volume, "Water Powers of Canada," which was published by the Commission in 1911, in which the subject was treated in a fairly complete manner in regard to the eastern provinces, the information covering the powers of the prairie provinces being admittedly very incomplete.

Following the policy enunciated in 1911, the Commission will, when the report by Mr. Arthur White on the British Columbia water powers is published, leave this field of investigation to the administrative branches of the public service. The Commission's object is to investigate, advise and inform. When its investigations have aroused the desired interest, its activities are directed to other fields. The "Water Powers of Canada," the volume under review, and the "British Columbia Water Powers," when published, will give in very handy form and in uniform style a thorough, condensed summary of the various water powers in Canada.

The information given is not so voluminous nor in so much detail as might be required by engineers proposing actual developments, but the circulation of these books will undoubtedly do much to interest Canadians and others in the development of these powers, and more complete information can then be secured by interested persons either from the Commission of Conservation or directly from the various departments more intimately connected with the administration of the water powers of the country, such as the Ontario Hydro-Electric Power Commission, the Nova Scotia Water Power Commission, the Quebec Streams Commission, the water power and irrigation branches of the Department of the Interior, etc.

The report is illustrated by sixty-three photographs and diagrams, besides two large maps, and has seven valuable appendices giving table of water powers on the Saskatchewan River and tributaries and streams flowing into Lake Winnipeg; tables of estimated flow and theoretical horse-power on streams where complete data on flow are not available; table showing descents on streams where lack of information prevents estimating flow; utilized water powers in the Yukon; monthly precipitation in prairie provinces; water power legislation; and bibliography.

In connection with these appendices it is interesting to note that the total available theoretical power, assuming most suitable conditions of regulated flow, amounts to no less than 865,000 h.p. on the Saskatchewan River and tributaries and streams flowing into Lake Winnipeg. Of this, only 109,000 h.p. has been developed. The estimated available theoretical power (May to November) on streams in the Prairie Provinces where complete data on flow are not available, totals about 5,500,000 h.p., of which approximately 240,000 h.p. is not favorable for development. (Naturally, this does not intimate, by any means, that all of the remainder can be developed economically.) Even this tremendous figure does not include streams where lack of information prevents estimating the flow. The utilized water powers in the Yukon are two in number, the power now being developed totaling 12,700 h.p.

The main portion of the report is divided into eighteen chapters, as follows:—

Winnipeg River; Red and Assiniboine Rivers; Western Tributaries of Lake Winnipeg; Eastern Tributaries of Lake Winnipeg; Nelson River and Tributaries and Hayes River; Saskatchewan River; North Saskatchewan River and Tributaries; South Saskatchewan River and Tributaries except Bow River; Milk River; Bow River below Calgary; Bow River above Calgary; Athabaska River and Tributaries; Eastern Tributaries of Lake Athabaska; Peace River; Slave River and Tributaries of Mackenzie River; Churchill River and Tributaries; Yukon River and Tributaries; Coppermine, Hood, Dubawnt, Ferguson and Kazan Rivers.

Mr. James White, Mr. Arthur White, Mr. Denis, Mr. Challies and the many other engineers who have had a hand in the preparation of these three volumes on Canada's water powers, are to be congratulated on the efficient manner in which this general survey of Canada's water power resources has been carried to completion.

PERSONAL.

W. ELLIS has been appointed chairman of the Hydro-Electric Power Commission of Hamilton, Ont.

GEORGE BURY, vice-president of the C.P.R., will leave Montreal shortly for Russia, to take control of the operations of the Russian railways.

Lieut. E. V. DEVERALL, of Toronto, a graduate of the School of Practical Science, 1915, has been given a commission with the 10th Royal Engineers of the Imperial Army. Lieut. Deverall was employed by the Dominion Bridge Co., Limited, before he enlisted.

ALAN SULLIVAN, secretary-treasurer of the Canadian Electrical Association, has completed arrangements by which he becomes the Canadian associate of Moses, Pope & Messer, consulting engineers of New York City. Mr. Sullivan will retain his official connection with the Electrical Association.

A. L. SMITH, formerly superintendent of the C.P.R. at London, Ont., who has been with that company for twenty-five years, has resigned to accept the presidency and general managership of the Algoma Eastern Railway. He will be succeeded by W. R. TANSLEY, formerly assistant superintendent.

N. R. NORMAN, who resigned his position as sales representative at Fredericton, N.B., for the Northern Electric Co., to enlist for foreign service in the Imperial Aviation Corps, and who is now in London, has been succeeded by CHARLES N. NISBET, for several years superintendent of the Sussex Electric Light Co.

PAUL J. MYLER has been appointed president of the Canadian Westinghouse Co., Hamilton, Ont. For a long time Mr. Myler was vice-president and general manager, but relinquished the duties of general manager some time ago. F. A. MERRICK has been appointed vice-president and general manager, and H. H. WESTINGHOUSE, the former president of the company, has been appointed to the position of chairman of the board, a new position which has been created.

Brigadier-General F. O. W. LOOMIS, proprietor of the firm of D. G. Loomis & Sons, general contractors, Montreal, who went to the front with the First Canadian Contingent, in command of the 13th Battalion (Royal Highlanders of Canada), and who for the past six months has been in France in command of the 2nd Canadian Brigade, has been awarded the D.S.O., and has also been made an officer of the Legion of Honor (France), and has been mentioned in despatches.

OBITUARY.

Sergt. HENRY SANDFIELD MacLEAN was killed in action in France on January 17th. He enlisted with the 88th Fusiliers of Victoria, B.C. He was the youngest brother of John S. MacLean, of the Canadian General Electric Co., Toronto, and son of the late Alexander MacLean, of Ottawa, formerly Canadian Trade Commissioner to Japan.

FRANK GILBERT, at one time a member of the firm of Gilbert Brothers, engineers and contractors, Montreal, died at Westmount on January 23rd at the age of 70. The firm did considerable work in the development of the Montreal harbor.

Major EDMUND HAZEN DRURY, assistant director of engineer services for Canada, died suddenly on January 31st at his residence in the Sifton Apartments, Ottawa, Ont. Major Drury, who was fifty-seven years of age, was born at St. John, N.B., and was a graduate of the Royal Military College, Kingston. He spent four years in Mexico with the Mexican Light and Power Co. He was in the original Hudson Bay Railway survey for the government and later was appointed chief engineer for the Chilean Longitudinal Railway, Chili, South America. Since the war he had occupied the important position on the headquarters staff of the Militia Department, now made vacant by his death. He was a member of the Canadian and American Societies of Civil Engineers.

ENGINEERS' CLUB OF TORONTO, ANNUAL

At the annual meeting of the Engineers' Club of Toronto, held on Thursday evening, February 1st, the following five directors were elected to serve for a term of three years: Messrs. C. H. Heys, W. A. Bucke, T. S. Young, Arthur Hewitt and T. D. LeMay.

JOINT COMMITTEE OF TECHNICAL ORGANIZATIONS, ONTARIO BRANCH.

The Ontario branch of the Joint Committee of Technical Organizations has recently sent out a circular letter outlining the work contemplated. The main lines along which the committee is at present working are as follow:

1. Co-operation with one or more of the following organizations: (a) The recently appointed Advisory Council on Industrial and Scientific Research; (b) Imperial Munitions Board; (c) National Service Commission; (d) The Canadian Engineers and other sections of the Department of Militia and Defence; (e) other government departments and commissions directly or indirectly connected with war work, such as the soldiers' aid committees.

2. Making preparations with a view to obtaining a comprehensive census of technical men with details of their qualifications, so that accurate information may be promptly available as to those most suited to render advice and assistance in different branches of technical war work.

Census cards necessary for the securing and classification of information covering the qualifications of the members of the various technical societies affiliated with the movement are now being prepared and will in the near future be forwarded to every member.

SOUTHWESTERN CONCRETE ASSOCIATION. Annual meeting and concrete show, Convention Hall, Kansas City, Mo., February 19-24, 1917. Chairman, Show Committee, Chas. A. Stevenson, 1433 West 10th Street, Kansas City, Mo.

IOWA ENGINEERING SOCIETY. Annual meeting, February 21-23. Secretary, J. H. Dunlap, Iowa City.

AMERICAN INSTITUTE OF MINING ENGINEERS. Meeting in New York City, February 19-22. Secretary, Bradley Stoughton, 29 W. 39th Street, New York City.

WISCONSIN ENGINEERING SOCIETY. Madison, Wis., February 15-16. Secretary, L. S. Smith, 939 University Avenue, Madison, Wis.

INDIANA SANITARY AND WATER-SUPPLY ASSOCIATION. Annual meeting in Indianapolis February 14-15. Secretary, W. F. King, Indianapolis, Ind

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

CENTRE STREET BRIDGE, CALGARY, ALBERTA*

SKEW BRIDGE WITH GRADE OF NEARLY FOUR PER CENT. AND TRAFFIC ON TWO LEVELS—COST APPROXIMATELY $400,000—ONE OF THE MOST IMPORTANT REINFORCED CONCRETE BRIDGES IN CANADA.

By GEORGE W. CRAIG, City Engineer, and JOHN F. GREENE, Bridge Engineer.

THE Centre Street Bridge improvement in Calgary, Alberta, consists of three parts: 1st, the bridge proper and its south approach with a total length of 1,300 ft.; 2nd, a fill and cut extending 2,100 ft. north from the bridge; 3rd, a side hill cut, forming a road which meets Centre Street at the face of the hill, extending west for 2,800 ft. (of which 2,300 ft. is in cut). The south end of the bridge lies five blocks from the business centre of the city.

The improvement provides a convenient avenue for traffic between two parts of the city; the one a residential section lying north of the river, and 120 ft. above the business portion which stands on the former flood plain on the south side of the river. The roadway has a maximum grade of 3.85% with a minimum width of 42 ft. on the bridge, and provides for two lines of street car traffic, and contains two sidewalks each 7 ft. wide.

A low-level roadway, 18 ft. wide, slung from the bridge deck, provides for highway traffic to a residential section lying on the flood plain north of the river below the bluff which commands the city, while the sidehill cut provides a means of communication between the low and hill levels north and west of the bridge.

The Bow River, which passes the bridge at an angle of 60° with the centre line, has a flood volume of about 55,000 second-feet, and is about 500 feet wide at the bridge site.

The problem from the viewpoint of the designer may be stated as follows: Given a height of 29 ft. from the water line to grade at the south bank, 47 ft., or 18 ft. more at the north bank, with a skew of 60°, to obtain a structure which shall provide for all probable traffic requirements on a high and low level during its life, and at the same time present an appearance in keeping with the dignity which should characterize public works of a monumental character, and this for a predetermined amount of money. We were impressed with the importance of lending to the structure the grace of proportion and of suitable ornament. The irregularities of grade and skew contributed much to the complexity of the problem, and it was only after numerous trial elevations based upon radically different conceptions, that we arrived at a final arrangement that seemed satisfactory. We went to the expense of constructing a wooden model of a portion of the bridge to be assured that the treatment would produce the desired effect.

Centre Street Bridge, Calgary, Alta. Photograph, August 21st, 1916.

The various parts of the bridge were designed for the following live loads:—

Floor, concentrated loads: Car beams and slab, 50-ton cars on both tracks; road beams and slabs, 20-ton motor trucks.

*Paper read before the Canadian Society of Civil Engineers, Montreal, February 8th, 1917.

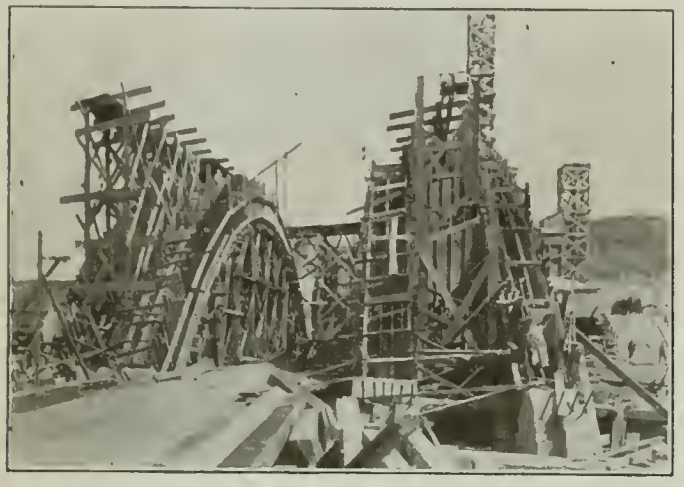
Uniform loads: Road, 100 lbs. per square foot; sidewalk, 100 lbs. per square foot on outside four feet, 40 lbs. per square foot on remainder.

Low level: Concentrated load, 20-ton motor truck; horizontal load, 300 lbs. per lineal foot of structure.

Arches: Concentrated loads, four 50-ton cars per 150 ft. span, with uniform loads on roadway and sidewalk, same as for the floor.

Temperature: Rise of 50° and fall of 70°.

Maximum stresses—Concrete: Floor, compression, 530 lbs. per square inch; arches, maximum compression



Falsework for one of the Arches. Looking North.

(live load and dead load) 540 lbs. per square inch; rib shortening, 677 lbs. per square inch; maximum tension, full load with 70° fall of temperature, 30 lbs. per square inch.

Steel: Maximum tension per square inch, 16,000 lbs.

Foundations: Maximum pressure upon rock, 12,300 lbs. per square foot.

Owing to the high cost of concrete materials, and to the depths of the piers and abutments, it was economical in obtaining the required carrying capacity in the arches to use deep, narrow ribs. Assuming a crown thickness of 5 ft., and placing the springing line of the flattest arch at low-water level, we found that there would be required two inner ribs, each 6 ft. wide, and two outer ribs, each 4 ft. wide.

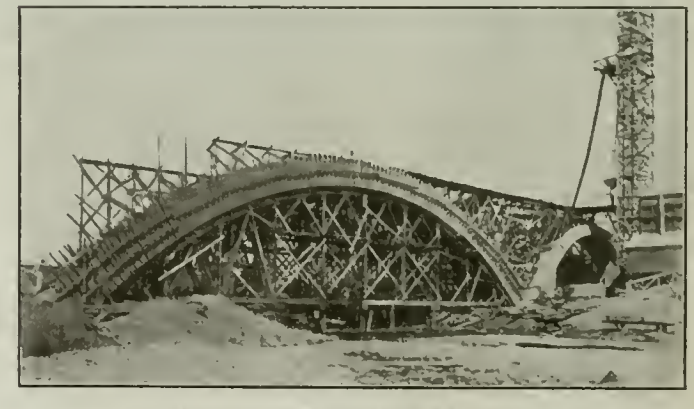
On the second arch retaining the same crown thickness and the same distance below the floor for the extrados at the crown, it was possible by taking advantage of the grade and increasing the rise of the arch, to reduce the width of the ribs, using two inner ribs at 5 ft. instead of 6 ft., and two outer ribs at 3 ft. 3 ins. instead of 4 ft. At the same time, by raising the springing line of the arch, we increased the moment arm of the thrust from the higher and narrower ribs, about the pier base, enough to offset the moment of the greater thrust from the lower and wider ribs. Again, on the third span, by increasing the rise we were enabled to use ribs 4 ft. wide and 2 ft. 6 ins. thick instead of 6 ft. and 4 ft. as on the shallowest span.

The piers are of the cellular type, the supports for the arch ribs resting on a concrete pedestal 5 ft. thick, extending over the entire area within the cofferdam. Those supports for the arches are connected by reinforced core walls 2 ft. thick, those between inner ribs constituting supports for the low-level deck, and those between inner and outer ribs rising to the upper deck, the whole pier presenting the appearance of two solid shafts. Manhole slabs have been provided in all piers and abutments for the convenience of the power, gas and telephone companies which have service mains on the bridge.

The retaining wall at the north end of the bridge is 48 ft. from base to top. The upper 12 ft. of the wall is of the cantilever slab type, the lower portion consisting of counterforts and slabs. The reaction from the cantilever slab portion is carried by the adjoining three feet of slab to adjacent counterforts, extra steel having been provided to carry this load.

The retaining wall at the south end has an umbrella-shaped top, the 4-inch sidewalk slab projecting several feet on both sides of the wall. Expansion joints have been provided at regular intervals in the wall, with lead strips 10 ins. wide to prevent seepage through the joints. The steel was of exceptional quality for re-rolled steel; the average ultimate tensile strength was 68,000 lbs. per square inch, and of 1,300 rods bent cold on tthe job, but four rods broke.

The problem of expansion joints for the floor was an unusual one, owing to the peculiar conditions. The spandrel ribs were designed as T-beams, with the floor slab for the flanges of the T. All floor beams are perpendicular to the centre line of the bridge, while the piers and abutments are skew. The accompanying plan of the floor system shows the method adopted. On each pier and abutment there was provided a heavy expansion beam upon which the system rested. Assuming the slabs over the box piers as fixed, the slabs on the arch spans moved to or from the expansion beam. Beams resting upon pier walls moved on steel plates in open pockets; slabs over piers rested only on the beams, a layer of clay 1 in. thick interposing between the wall and the bottom of the slab. Joints over the arch spans were made in the slab midway between beams, the slabs in these expansion panels having been designed as cantilevers. Troughs covered with lead were provided at all expansion joints, these troughs draining into pipes provided in the piers. Passing from the utilitarian to the aesthetic aspect of the design, one must bear in mind that the treatment of the parapet, piers and abutments should please and impress favorably both the distant observer, who will view the structure *in toto*, and



Another View Showing Falsework.

also the more frequent observer, who will view it from the sidewalk or from the passing automobile.

For the close-ranged observer we have provided four ornamental kiosks, and a massive concrete parapet of premoulded concrete balusters, base and rail. The kiosks span the sidewalk and open on observation balconies cantilevered from the side walls. The east and west faces expose shields containing the emblems of the various parts of the British Empire, the maple leaf

for Canada, the rose for England, the shamrock for Ireland, and the thistle for Scotland. Above the north and south faces and over the walks are buffalo heads, emblematic of Western Canada; the whole forming a pedestal of a massive British lion, 13 ft. long by 7 ft. high. The ensemble is symbolical of the permanence and stability of the British Empire supported by its component parts.

The piers are surmounted by slotted battlements treated with steel grill work. The plan of the pier parapet is a half hexagon. Inasmuch as the skew of the bridge is 60° an angle of the hexagon forms a nose or cutwater at the upstream face of the pier, while at the same time presenting a symmetrical elevation to the passing observer.

The illumination of the bridge will be effected through the agency of fluted cast-iron standard on the piers, and four torch bracket lights on each kiosk. All iron work will be painted of a gray color, which will nearly match the concrete.

For the distant observer viewing the bridge as a whole, an attempt has been made to break up the dull flat surfaces which from their extent and from the sameness of color impress one unfavorably. Working from the hypothesis that it is neither expedient nor economical to eliminate board marks from concrete faces, we have adopted the policy of substituting grooves and pilasters which will serve both to withdraw the eye from the necessary minor irregularities of the concrete surfaces, to break up the surfaces, and to heighten the effects aimed at, whether of depth by the use of vertical lines or of breadth by the use of horizontal lines. The faces of the piers have been panelled and grooved; the faces of abutments have been pilastered and the form sheeting has been run up and down to convey an impression of greater height. The arch rings were grooved at regular intervals, serving the double purpose of breaking up the rib face, and of offering suitable locations for construction bulkheads. The face of the north retaining wall was broken up by horizontal grooves and by battered pilasters, marking the locations of the counterforts on the back of the wall, and carried up above the rake of the wall, breaking the skyline.

The 62-ft. arch spanning the boulevard on the north side of the river supported deep spandrel walls, the faces of which were marked with pilasters, and the arch was crowned with a large date stone, and a seal of the city of Calgary 6 ft. high by 4 ft. wide.

The low-level structure with a roadway 18 ft. wide, consists of a structural steel frame, with a concrete floor slab, and an asphaltic concrete wearing surface. It is suspended by hangers, each consisting of two steel angles engaging a pin, and linked to steel bars with an eye on one end and a thread upon the other. The threaded end passes through a yoke consisting of two 7-in. channels with top and bottom cover plates. These yokes are embedded in the main floor beams with the bottom of the yoke 18 ins. from the bottom of the beam.

The concrete slabs for the low-level consisted of premoulded blocks suitably reinforced, 4 ft. by 3 ft. 8 ins.; each slab was a double T with flanges 3 ins. thick, and the stems projecting 4 ins. below the slab. These blocks rest on the top flanges of the steel I-beam stringers. This unusual type of slab was adopted for two reasons: 1st, to reduce the dead load weight of the structure; 2nd, to permit of the completion of the erection in the dead of winter with a temperature at zero or less.

From the standpoint of economics with cement at $2.40 a barrel and structural steel at $80 a ton, the adopted design cost 40c. per square foot against 58c. per square foot for the standard design, with a 6-in. slab and I-beam stringers.

The spandrel arches were designed as beams continuous over three spans, all moments and shears being worked out for concentrated loads by means of the three-moment equation. Expansion joints have been provided in these spandrel walls, layers of three-ply roofing intervening between adjacent parts.

Joints at the one-third points in the arch spans allow for the opening due to the rise of the arch with a rise in

View from the East, Centre Street Bridge. Photograph, January 15th, 1917.

temperature, and joints at the piers and abutments provide for the fall of the arch with a drop in temperature, and the consequent drawing away of the spandrel walls from the piers.

Economic depths of beams and slabs as determined by the local costs of cement, sand, gravel, lumber and steel have been ascertained by the well-known principles of maxima and minima of differential calculas, the process entailing the writing of an equation for the cost of the material for the beams in terms of money and depth, and solving for the depth which will make the cost a minimum.

The concrete for the arches, beams, slabs and retaining walls was prepared in the proportion of one part of cement, two of sand, and four of gravel; the foundations and all pier and abutment walls 1:2.5:5; the handrail 1 of cement to 2.5 of sand.

The cement was purchased upon the specifications of the Canadian Society of Civil Engineers, with the exception of the tensile strength requirements for 1:3 mortar; these were raised from 150 to 200 lbs. per square inch for 7 days; and from 225 to 275 per square inch for 28 days. The product of the Canada Cement Company met this requirement.

A washed screened sand was required according to the specification with grading clauses, rejecting sand with more than 40%, by weight, passing a No. 30 screen; or more than 3% passing a No. 100 screen. The gravel, washed and screened, was purchased upon a void specification, the maximum not to exceed 40%. The maximum diameter of particles for use in piers, arches and walls was approximately 5 ins., this limitation being due to the efficiency of the mixing machine, not to a probable diminution in the strength of the resulting aggregate. In the floor system, owing to the intricate network of steel, it was necessary to limit the maximum diameter to 2 ins. Whenever expedient, as in piers and abutments, boulders were embedded in the concrete.

Active construction work upon the bridge began in April, 1915; in June the Bow River went into a flood, reaching a peak on the 26th, the highest since 1897. On

this day the temporary bridge used as a traffic way during the construction of the bridge was washed out. Mr. Craig and City Commissioner Garden were on the structure at the time. The former made his way to shore by climbing a panel of the deck, one end of which was in the water. Mr. Garden was swept downstream, pursued by two of the bridgemen who had put off after him in a boat provided for such an emergency. They succeeded in landing him on an island about a mile downstream.

Soundings at the piers disclosed the following substrata: In pier No. 1, gravel and large boulders, 5 ft.; clay, 3 ft.; soft shale, 4 ft.; sandstone, 4 ft.; clay, 3 ft.; hard shale, 15 ft. to limit of drilling. In pier No. 2, gravel and large boulders, 5 ft.; clay, 2 ft.; sandstone, 4 ft.; soft shale, 5 ft.; sandstone, 5 ft.; hard shale for 15 ft. to limit of drilling.

Experience with the river upon other bridge foundations taught us that we must guard especially against a possible great scour. Shifting gravel bars situated both above and below the bridge tend to restrict the flow to certain channels, and in times of flood with attendant high velocities, there is a considerable scour in these channels. Hence, to provide adequate protection against scour, we carried our excavation through the bottom layer of sandstone and well into the hard shale rock beneath. The shale rock was of a quality such that there could be no question of exceeding the allowable bearing power.

The cofferdams consisted of two layers of Wakefield sheet piling, with an 8-ft. puddle. The sheet piling was driven to refusal in the gravel, centrifugal pumps were installed, the dam pumped dry, excavation commenced on the general plan of removing the material under the sheet piling first, driving the latter home and then removing the material in the middle. When the sheet piling had penetrated the clay underlying the gravel, a layer of 3-in. plank was driven approximately to the sandstone level. The material was broken up by blasting and removed in skips by a derrick. There was considerable leakage from the gravel and boulders, the water rising between the sheet piles and the planking; and at the beginning it was necessary to operate four centrifugal pumps to keep the water down to a working level. After penetrating the clay one could hold the water ordinarily with one pump.

In the construction of pier 2 work was discontinued in the middle of January after a cold spell in which the temperature had dropped to 46° below zero. The excavation was still in the gravel.

Upon recommencing work late in March it was found that the ice had so disrupted the cofferdam that it was impossible to lower the water to a working level. The puddle was frozen solid, and the ice inside the cofferdam was approximately 4 ft. thick. The choice of action lay between digging out the entire puddle, replacing it with a new one, or digging out only such portion as was necessary to stop the worst leaks. Proceeding on the assumption that it was cheaper to risk a few blow-outs than to remove and replace the puddle, we adopted the latter mehod, and completed the excavation after various mishaps, including three minor and one major blow-out, the latter flooding the hole so quickly that there was not sufficient time to accomplish the removal of the four pumps which were sitting below water level; one of these, with its motor, was flooded. We found that after plugging a blowout the dam would hold tight for about 72 hours; the jar resulting from the operation of the steam drill and from the blasting together with the gradual melting and disintegration of the frozen puddle, would start new leaks, which quickly attained sufficient proportions to require attention. The pumps, all centrifugals, were operated with check valves on the exhaust pipes, under an average suction lift of 19 ft. and a maximum of 23 ft. The pier work was a continuous operation carried out in three shifts dails of 8 hours each. Work upon this pier began on March 23rd and the concreting of the pier had begun on April 14th. It was evident that in order to prepare the bridge ready for traffic in 1916 it would be necessary to complete the concreting of two of the river arches before high-water, thereby permitting the completion of the superstructure of most of the bridge before the subsidence of the water. A conservative estimate of the earliest probable date of the flood, made after an examination of the records of the Irrigation Department and after conferences with those most familiar with the local river conditions, placed it as June 1st.

The work was so conducted by the employment of double shifts of carpenters working from dawn to dark, that the concreting of the key of the second arch had been completed on May 19th. The removal of falsework on this span began after four weeks, on June 13th. On June 19th, when all the falsework above the pile caps had been removed, the flood came, reaching an elevation within a foot of the record flood of 1915, and washing out five bents of piles in arch No. 3.

Each pair of ribs in an arch span was concreted in eight sections, four on each side of the crown, beginning with a section at the crown, to prevent a rise of the falsework in the middle, and then working up from the haunches. This method of concreting in small sections not only reduced the initial stresses due to contraction of the concrete in hardening, but also lessened the excessive load due to the 60° skew of the piers upon the forms on the low side of the arch ribs. This load was so great that we found it, upon trial, inexpedient to use No. 6 wire and necessary to resort to ⅜-in. rods spaced about 3 ft. centres, to hold the side forms.

All concrete, both in the arches and in the deck, was transported from a mixing plant located at the north shore in hand-pushed buggies run on temporary runways. As a matter of economics the cost of placing concrete in the arches, including charges for plant and shop, was $1.02 per yard.

The design of the bridge was such that a high-speed plant for conveying concrete was inexpedient and uneconomical. With a total length of approximately 1,000 ft. and a yardage above ground of 7,000 yards, the cost of distribution per yard by a system of towers and chutes would have exceeded that of the method adopted. The construction of an economically designed reinforced concrete bridge proceeds in a series of well-defined steps; the concreting of sections of the arch rings, the spandrel columns, the spandrel arches, and the floor, run in sections from expansion joint to expansion joint. The maximum run for a day was 173 yards, the average daily run about 60 yards.

The allowable stresses assumed for the design presupposed an excellent grade of concrete. Such a concrete may be obtained after a proper proportioning and mixing, only by a careful supervision of the final disposition of the material, after release from the conveyer. Proceeding upon the assumption that the concrete shall contain the least quantity of water consistent with the quality of being "alive," that mortar pockets and rock pockets are points of weakness; that no vehicle will deposit concrete in forms in a proper condition; it followed necessarily that

every batch of concrete deposited in its final resting place required testing and handling to insure the quality desired. Previous experience with the chuting system on bridge work disclosed the existence of two great attendant evils—the temptation to grease the chute with an excessive amount of water, and the tendency to operate the mixing and conveying portion of the plant at maximum capacity, regardless of the capacity of the placing crew to handle the material properly. By a judicious combination of both evils the material may be placed at a minimum of expense, but the resulting aggregate may have a compressive strength of less than half that of a properly handled concrete. Conveying the concrete by the push-buggy method, we not only remove the incentive for sweetening the concrete with water but also deposit the material of a proper consistency in small batches at regular intervals in such a manner that the final handling is facilitated greatly.

The concrete handrail, consisting of a top and bottom rail with a turned baluster, was made by the dry process. The bottom rail was moulded in place; the top rail was cast upon the sidewalk adjoining its panel; the balusters were made in the construction yard, and the posts were cast in place after the assembling of the above-mentioned precast parts. The best production record in making balusters with two men working with one cast-iron mould was 65 balusters in 11 hours.

The ornamental work, consisting of the panel 6 ft. by 4 ft. containing the seal of the city of Calgary, the small shields on the kiosks, and the lions, were made by the dry process. A full-sized model of the lion, 13 ft. long by 6 ft. wide by 7 ft. high, was done in clay; a plaster cast, consisting of a shell about an inch thick, and containing over 400 pieces, was fitted over this model; and a heavy 4-in. coat of plaster forming large supports for the smaller pieces of the inner coat of plaster, was cast upon the outside. The lions were then cast each in five pieces. All artistic work in connection with the modelling and making of plaster casts was done by J. L. Thompson, of Calgary.

The second portion of the improvement, consisting of a cut and fill extending north from the bridge 2,100 ft., was started in the fall of 1914. The first cut was made with an outfit consisting of two elevating graders with teams and wagons. The work was difficult and expensive in that it was necessary to build up a dump at the edge of a steep cliff.

During the following summer a 60-ton "Marion" shovel was installed in the cut; the loaded dump cars were lowered down on the dump, controlled from a steam hoist set at the north end of the cut. The building of the dump was accomplished without the aid of a construction trestle, the raising of the tracks going on simultaneously with the building of the dump. Work was discontinued in the fall of 1915; the Centre Street cut and the side hill cut, 2,800 ft. long, were completed during 1916. The total yardage of earth moved was approximately 220,000.

The total cost of the improvement, including $34,000 for condemnation and right-of-way, was $400,000.

The improvement was conducted under the direction of George W. Craig, city engineer, with John F. Greene as bridge engineer in charge of the design and the construction of the bridge. The writers were assisted in the design by Frank Lawson, lieutenant, 56th Canadian Overseas Contingent, who was killed at St. Eloi in April, 1916, and by J. Bernard Richards.

The construction work was done under the day-labor method with James Patterson as construction superintendent. The earthwork north of the bridge and a portion of the foundation was carried on under C. M. Arnold as resident engineer in 1915, and the balance of the grading work was carried on under C. LeB. Miles in 1916.

In discussing the above paper at the meeting of the Canadian Society of Civil Engineers held at Montreal last Thursday evening, Col. J. S. Dennis called attention to the phrase, "whenever expedient, as in piers and abutments, boulders were embedded in the concrete," and asked whether that method of construction was approved. What percentage of boulders would one be justified in using? he asked.

Mr. J. A. Jamieson replied that, other things receiving due consideration, it might be better to have a certain amount of boulders in the concrete, provided that they are well embedded, but this has to be done with a good deal of care so that the boulders shall be pretty evenly distributed, otherwise the stress in the concrete would be uneven. The more stone that can be put into the concrete, provided it is well embedded, the better. It would be difficult to name any given percentage of stone to be used, because there are so many factors that enter into the problem.

Mr. Jamieson also called attention to the fact that the question had been raised in this paper of the relative merits of spouting concrete, compared with other means of distributing it. He said that his experience had been that, with very great care, a thoroughly good job may be made by spouting concrete, but that it is so rarely accomplished that, generally speaking, he is very much opposed to this method. As a rule, altogether too much water is used in order to get the concrete to spout well.

Mr. Jamieson also noted that the cement for this bridge was required to pass mortar tests for seven days and twenty-eight days that were different than those called for by the Society's specifications. Personally he thought that the changes were not advisable, as they tended toward a cement that might retrogress. All cements that give a very high test on short periods are apt to retrogress. He expressed a preference for cements which are comparatively low at short periods and show good increases at greater age, along the lines of the British standard specifications.

Chicago's big drainage scheme, which tapped Lake Michigan and started the waters of the Great Lakes flowing towards the Mississippi, has proven inadequate for her present needs, and now she proposes deepening the drainage canal and drawing much more copiously upon the waters of Lake Michigan. The State of Illinois sees in this new deep-water canal project a boom for Illinois shipping and has voted $20,000,000 for the purpose, and is now asking the consent of the United States Government to the project. It is not yet certain just how much this diversion of the waters of Lake Michigan would affect the levels of the Great Lakes, but the issues at stake are too great to permit running any great risk. The State of New York and the Province of Ontario are both vitally concerned in the matter, as the lowering of the levels of Lake Erie and Ontario would affect every harbor upon them and might seriously interfere with the Welland Canal, and even with the St. Lawrence canals, and might make the Detroit River channel almost useless for big boats. Whether the project will be held up by Congress is yet to be seen, but if it goes through, then both the State of New York and the Province of Ontario will have to hold the United States Government responsible for any damage which may result.

STONE-FILLED SHEET ASPHALT PAVEMENT.

By Charles A. Mullen,
Director of Paving Dept., Milton-Hersey Co., Montreal.

STONE-FILLED sheet asphalt pavements have been laid in Montreal on Mountain Street up the steep grade north of Sherbrooke Street, on a section of Sherbrooke Street in Notre Dame de Grace west of Westmount, on Mansfield Street between Sherbrooke and Burnside Streets in front of the University Club and the Canadian Society of Civil Engineers' building, on Smith Street between McCord Street and Murray Street, and on many other streets carrying light, medium or heavy traffic. On Smith Street, it is subjected to the numerous and intensively heavy traffic of a destructive character that crosses the Wellington Street bridge from the freight yards and docks.

These pavements are not of the very highest quality, as the municipal plants of Montreal have not yet been organized fully so as to get the best possible results, but they are fairly good types of this construction and will probably give service for a number of years to come. The surface on Mansfield Street was laid over an old bituminous macadam.

The stone-filled sheet asphalt surfaces are apt to look somewhat rough when first laid, but this initial roughness passes away after one or two summers' traffic, and leaves a surface almost as smooth as that of the usual sheet asphalt, and has a pleasing mosaic appearance when clear enough for the stone-chips in the surface to be seen.

The construction of these stone-filled asphalt pavements in Montreal was the result of the writer's recommendations to the city engineer.

There is nothing radical or new about these pavements. The altered mixtures and the methods of laying are rather a getting back to earlier practices that have, in the light of experience, proven both correct and economical. What has actually been done is to eliminate entirely the so-called binder course, and to introduce into the surface mixture, as formerly laid, sufficient ¼-inch stone chips to have in the completed mixture between 25 and 30 per cent. of this material. The two items should be considered entirely independent of each other, as either change might be made to advantage even without the other.

As regards the stone-filled mixture, it has been in successful use to a limited extent for more than forty years. De Sales Avenue in Washington, D.C., was laid with such a mixture in 1875; and about a million square yards were laid in Pittsburg about 1890. The writer first laid it extensively in Milwaukee during 1910 and 1911, and in Schenectady during 1912 and 1913. Similar mixtures, not always carefully executed, are now being used extensively in all parts of the United States and in some parts of Canada.

Noteworthy instances of this type of asphalt surface of which the writer has personal knowledge are the pavements laid upon Riverside Drive, New York City, and South Centre Street, Schenectady. The Riverside Drive pavement carries very heavy autobus and fast automobile traffic in large numbers; and the South Centre Street pavement carries heavy draying between freight stations and industrial plants on a roadway but 20 feet between curbs. Both of these streets were laid during the season of 1913, and neither has yet given any indication of failure.

The stone-filled sheet asphalt pavement has demonstrated its ability to withstand both heavy slow-moving traffic on iron-tired, horse-drawn vehicles, and heavy fast-moving traffic on rubber-tired, self-propelled vehicles. It is both desirable and economical for use on the heavy-traffic business streets of a city, and its actual cost is so low that it is the most economical pavement for light residential streets and boulevards. It should therefore be adopted by most cities as the standard form of pavement construction, and varied from only where a too steep grade or other special condition makes it imperative to do so.

Roughly speaking, the differences in the proportioning and the costs of the materials entering into the two mixtures, figured for a square yard two inches thick and weighing about 200 pounds, are about as follows:

	Sheet asphalt.		Stone-Filled.	
Material and costs.	Lbs.	Cost.	Lbs.	Cost.
Asphalt cement	25		20	
@ $.01 per lb.		$.25		$.20
Inorganic filler	30		20	
@ $.0025 per lb.		$.075		$.05
Graded sand	145		100	
@ $.0005 per lb.		$.0725		$.05
Clean stone chips	none		60	
@ $.0008 per lb.				$.048
Total weight	200		200	
Total cost		$.3975		$.348

The costs of materials vary in every locality, and the exact proportions vary with the characteristics of the local supplies. There is always a slight difference in the specific gravity of the two mixtures. These and other interesting variables, however, are not of sufficient importance to be considered here.

It may be assumed that in nearly every case the stone-filled sheet asphalt mixture will cost about five cents per square yard less than the mixture without the stone-filling. While such a saving is well worth consideration, it is not on that account that the writer has advocated the use of the mixture containing the stone chips, but because, even at the same or a slightly higher cost, he considers it a better and more economical pavement surface than the other. It retains the merits of the usual sheet asphalt and combines with them certain other features that are very desirable and well worth considering.

The advantages of the stone-filled sheet asphalt mixture over the mixture without the stone chips, are as follows: (1) It is less slippery; (2) it marks up less in summer; (3) it is easier of traction in summer; (4) it is less liable to displacement; (5) it costs less.

The pavement should be looked upon as a standard sheet asphalt mixture to which has been added a certain percentage of fine stone chips, not in any case exceeding 30 per cent., to act as a reinforcement and thereby produce the physical results noted above. It is not a true asphaltic concrete, nor is it intended or desired to be such.

Eliminating the Binder Course.—The best reason for the elimination of the so-called binder course used as an intermediate course between a sheet asphalt pavement and a concrete foundation is that no legitimate reason has yet

been advanced why it should be there; and it costs, laid in place, about 25 cents per square yard. It would seem that before a city laid out such a sum of money on each square yard of its asphalt paving, it would know why it was doing so, and that it would get value for the money. The writer has asked many city engineers the reason they were laying the binder course, and has not yet received a good answer from any of them; he has asked many of the country's best experts, and they have also failed to enlighten him. Several have attempted laborious and far-fetched excuses for its existence, while others, principally the older practical men who grew up in the industry, have "just smiled."

In the first place, let us understand that the so-called binder course is not, properly speaking, a binder course at all, but an intermediate course that will have to explain its being on some other grounds. The paint coat is the only real binder course, and that is not good practice for several reasons, the principal of which is that it is not needed. The so-called binder course does not adhere to the concrete foundation any more than does the wearing surface proper when that is laid upon it direct. Either can be removed with equal ease, there being no bond at all between them and the concrete foundation; and in fact, none is required.

The development of intermediate constructions between sheet asphalt pavements and their concrete foundations has been as follows:

First, we had the so-called cushion coat, which consisted of a layer of the top course put in place and tamped before the final layer was placed. The principal reason for this construction seems to have been to secure proper compression on a greater thickness at that time believed to be required. Other theories were developed for its use; but all have since proven fallacious, and the cushion coat has been abandoned everywhere. It differed from the top mixture only in that less stone dust and proportionately more asphalt cement were used, and, as it was to be buried at the bottom, no one thought it necessary to bother making it very good.

Then we had the paint coat, which was exactly what its name implies,—a coat of naphtha and asphalt paint applied to the concrete foundation before the surface was laid. This coat of asphaltic paint penetrated a short way into the surface with the naphtha and then melted again under the hot asphalt surface and bound to that. It was a real binder course, as any one knows who has had to make repairs on streets where it had been used. Finally, some one seems to have tumbled to the fact that the asphalt surface was quite willing to remain upon the concrete foundation without being bound there, and the paint coat has not been laid to any great extent for a number of years. A useless expense and a good riddance.

Next we had the open binder, which consisted of ¾-inch crushed stone coated with asphalt cement and laid in a course 1 inch thick upon the concrete foundation before the asphalt wearing surface was placed. This was useful in covering up the incompetence of contractors and engineers when they had laid such a poorly lined-up concrete foundation that wearing surface could not be laid upon it until some cheaper mixture had first been used to level it up, so the cities on this continent invested several millions of dollars in this needless material. Then some bystander, who had a presentiment of a large special assessment on the way, happened to ask why the so-called binder course was being bought and paid for with his money.

The question was a poser. It would not do for the engineers and experts to admit that they had been squandering public money on something the reason for which they did not know, so they improved the open binder course by putting a little sand in it and calling it a closed binder course. Now, the open binder course is quite universally condemned as being an actual detriment to asphaltan pavement, and the virtues of the closed binder course are freely extolled, without being very definitely stated.

The so-called closed binder course, when well laid, is a "bitulithic" pavement. When used as a wearing course, it is covered by certain letters patent that have created a new and useful monopoly in the paving field. It appears to be quite customary to lay asphalt wearing surfaces on top of such pavements and then call them closed binder courses, thereby making sure they won't wear out and at the same time avoiding the patents.

Actual Size Photograph of Surface of Stone-filled Sheet Asphalt Pavement, as Laid in Montreal, After Being Rubbed Down on Marble Bed.

Possibly some one can state a sound reason for laying a second-rate pavement surface under a first-rate one; the writer cannot.

The most commonly advanced argument in favor of the use of the so-called binder course is the claim that it prevents the surface from shoving. The writer has seen many instances of shoved or displaced pavements, but he has never seen a properly constructed asphalt pavement shove, nor has he seen an instance where a binder course has kept a poorly-constructed pavement from shoving; and certainly he has seen a number of poorly constructed asphalt pavements shove, both with and without binder courses. But even if a so-called binder course would keep a poorly constructed pavement from shoving, as some of its advocates claim, there seems no reason why a city should pay 25 cents or more per square yard to secure a result that would be equally obtained by an additional expenditure of not to exceed 5 to 10 cents per square yard for additional materials and services to secure a high-grade asphalt pavement without such a binder course.

There is one other reason for not using a binder course. The future maintenance of asphalt pavements will very largely be accomplished by the re-use of the old surface materials, and thereby at greatly reduced costs. When we get to that, the binder course will prove itself an unmitigated nuisance; but that is a subject for another story.

HYDRO-ELECTRIC POWER PLANT OF THE CEDARS RAPIDS MANUFACTURING AND POWER COMPANY.*

By Henry Holgate, M.Can.Soc.C.E.

BEFORE going into the details of this work, it will be well to study some of the larger physical elements which govern conditions on the St. Lawrence River, and to consider what may be called the legal and political conditions governing the use of the river for purposes other than navigation, as well as the factors that control the acquisition of property necessary for the development of power.

The data published in the report of the International Waterways Commission for 1910 shows clearly the prominent characteristics of the area drained by the St. Lawrence River.

An extract from this report is as follows:—

"The Great Lakes constitute a series of enormous natural reservoirs, each of which serves to regulate the flow in the river constituting its outlet, and to maintain the lake below. They are interdependent. The study of one, to be complete, must include the study of all. The total area drained by them is about 287,688 square miles. Of this total, about one-third is occupied by the lakes themselves; that is, is devoted to reservoir purposes. The result is a uniformity of level and a uniformity of flow which is truly wonderful. In Table A are given the areas of the lake surfaces and of the drainage basins.

Table A.

Lake.	Area of lake surface in sq. miles	Drainage area including lake surface in sq. miles.	Ratio of lake to drainage area.
Superior ...	32,060	76,134	1 ; 2.37
Michigan ...	22,336	65,799	1 ; 2.95
Huron	22,978	72,008	1 ; 3.13
St. Clair	503	6,194	1 ; 12.31
Erie	9,968	34,573	1 ; 3.47
Ontario	7,243	32,980	1 ; 4.55
	95,088	287,688	1 ; 3.02

Authority: 1906 U.S. Lake Survey Report.

The areas of the small lakes and streams are taken as a part of the land area.

In Table B are given the average and the extreme variations in the levels during the period from 1860 to 1907.

"No work of man ever has approached or ever will approach this perfection of regulation."

Comment on the above is unnecessary, but we must be impressed by the fact that the flow of this great river is regulated by nature within such narrow limits, as to justify the claim that "no work of man has ever approached or ever will approach this perfection of regulation." Nature having provided us with this great river, already perfectly regulated, with vast storage reservoirs, it is incumbent on us to make the most efficient use of it.

Primarily the river must serve both present and future demands regarding navigation. Thus the probability of the deep navigation channel being in the river itself, and not wholly in a system of lateral canals, must be kept in mind, and no works must be permitted which would prejudice future development of navigation on a deep-water scale as set by the dimensions of the new Welland Canal now being constructed.

The St. Lawrence River, after passing Cornwall, expands into Lake St. Francis, and this lake discharges at Coteau through the Coteau Rapids, where there is a fall of about 17 ft. Then follow the Cedars Rapids with a fall of about 32 ft., and the river enters Lake St. Louis through the Cascade and Split Rock Rapids, having a further fall of about 17 ft. The difference of elevation between Lake St. Francis and Lake St. Louis is about 81.5 ft. The distance from the outlet of Lake St. Francis to the entrance of Lake St. Louis is 11 miles. The whole of this stretch of river is in Canada, but a small part of the shore of Lake St. Francis, below the 45th parallel of latitude, is in the State of New York.

The rapids are navigable down stream for seven months of the year for boats of 5 ft. 6 ins. draft. The Soulanges Canal on the north side of the river affords navigation from Lake St. Francis to Lake St. Louis for vessels of 14 ft. draft, and is a portion of the 14-ft. channel from Lake Ontario to Montreal. The Cedars Rapids are about 30 miles west of Montreal.

Table B.

	Superior Ft.	Huron Ft.	Erie Ft.	Ontario Ft.
Extreme range, 1860-1907	3.32	4.64	3.89	5.54
Maximum range in 1 year	(1869) 2.67	(1876) 1.94	(1892) 2.28	(1867) 3.65
Minimum range in 1 year	(1891) 0.49	(1879) 0.59	(1893) 0.87	(1907) 0.79
Average annual range	1.18	1.21	1.56	1.93

In Table C are given the average and the extreme variations in the discharge of the outlets for the period 1860 to 1907:—

Table C.

	St. Mary's River.	Detroit River.	Niagara River.	St. Lawrence River at its head.
	c. f. s.	c. f. s.	c. f. s.	c. f. s.
Average discharge for entire period	82,000	204,200	212,200	254,500
Greatest excess average for any one month.	46,700	71,200	45,600	96,800
	Sept., 1869, 57%	July, 1883, 35%	June, 1876, 21%	May, 1862, 38%
Greatest excess average for any one year ...	19,100	30,200	26,500	49,000
	1876, 23%	1885, 15%	1876, 12%	1862, 19%
Greatest deficiency average for any one month	33,800	98,900	43,500	102,200
	Feb., 1893, 51%	Feb., 1874, 48%	Mar., 1896, 20%	Feb., 1902, 40%
Greatest deficiency average for any one year	16,900	30,600	31,800	62,800
	1879, 21%	1896, 15%	1895, 15%	1895, 25%

*Abstract of paper read before the Canadian Society of Civil Engineers, Montreal, November 4th, 1915.

The St. Lawrence being a boundary river, and its relation to Canada and the United States having been defined in various treaties between Great Britain and the United States, all questions in regard to it are international questions, and are now referred to the Joint High Commission under the treaty of 1910.

In my communication to the Society dated March 16th, 1911, the international features which control the St. Lawrence River were described, and though the Cedars Rapids development is on a part of the river entirely within Canada, yet on account of the river being an international highway from the Great Lakes to the sea, it was necessary to submit the company's proposals to the International Waterways Commission, so as to ensure that nothing detrimental to either country was contemplated. This Commission, which was the predecessor of the present Joint High Commission, examined the project and reported favorably on it. Such action was necessary before the government of Canada would consider the granting of any privileges.

The Cedars Rapids Manufacturing and Power Company was incorporated by Act of Parliament of Canada in 1904, the Act being amended in 1909, and has power to expropriate land under the terms of the Railway Act. The incorporators proceeded to acquire the necessary land on the north side of the river, along a frontage of 1½ miles, from Point du Moulin at the foot of the rapids, to Cedars Point at the head. Two islands in the river. Isle Bedard and Isle aux Vaches, were also acquired.

An agreement was made with the government of Canada in 1909, after the International Waterways Commission reported favorably on the project, whereby the company was permitted to divert 56,000 c.f.s. for its power development, this being the amount allowed by the Commission so as not to interfere with navigation.

Under the existing interpretation of the law, the St. Lawrence being a navigable river, the bed belongs to the Crown, and no riparian owner can construct works in the river bed without consent of the Crown. The Crown is represented by the province in which the river lies. The province also assumes the ownership of the water flowing over the river bed, but will not grant rights in a navigable river until the Federal Government approves on the ground of non-interference with navigation.

The company therefore applied for and obtained a lease for 99 years of the bed of the river from the province of Quebec, at an annual rental, and agreed to pay also for the use of the water at fixed rates per horse-power output of the power house, these rates increasing as the output increases, so as not to burden the initial development with too heavy a fixed charge. The agreement with the government of Canada did not give authority to place structures in the river, except in the sense that the placing of such structures and the diversion of the quantity of water, as approved by the Commission, would not obstruct navigation.

The above measures placed the company in good legal standing, and the acquisition of lands was completed with the exception of three properties belonging to one estate: (1) certain "reserves" on Point du Moulin covering water power and mill site, roadways, etc., the land itself, however, having been deeded to the company subject to such reservations; (2) Isle Bedard, having an area of 3½ acres; (3) Isle aux Vaches, having an area of 28 acres.

The company proceeded under the Railway Act to expropriate these properties and offered for the "reserves" on Point du Moulin $1,700; for the Isle Bedard, $200; and for Isle aux Vaches, $2,800, these figures being based on the value of similar land for agricultural purposes. Two of the arbitrators signed an award agreeing that the company's offer was ample, while a third fyled a minority award stating that he would have been prepared to award $80,000 for the "reserves," $34,000 for Isle Bedard and $62,000 for Isle aux Vaches, the basis of the valuation differing completely from that of the company.

The matter in dispute has been the subject of litigation in the Superior Court, and before the Privy Council, and is still unsettled. Many different views have been put forward in regard to the proper basis of valuation for such properties when they form an integral part of an engineering project, and these, together with the final judgments, will prove of great interest to the profession.

The various legal steps necessary to complete the title and rights were taken in good time, so that there were no legal obstacles to hinder progress when financial arrangements had been made, and the time for construction had arrived.

The country adjacent to Cedars Rapids is typical of the St. Lawrence Valley. The subsoil consists of stiff clay, containing large and small boulders, overlying limestone formation. The river bed is formed generally of boulders resting on hardpan, with outcroppings of rock in the rapids. The land is level and well settled, and being close to a large city and accessible by rail and water, the difficulties generally met with in developing water power in remote localities do not arise.

Railway communication to the vicinity of the site is rapid and frequent, highways are numerous and fairly good, and the Soulanges and Lachine Canals give communication with Montreal by boats of 14 ft. draft during the navigation season. Westwards, the Soulanges and other canals communicate with the Great Lakes. The canals are operated by the Dominion Government, and are free of tolls.

At Cedars Rapids the greatest recorded variation between high and low-water levels in one season is four feet, the usual variation being two feet. Between the highest and lowest recorded levels there is a difference of seven feet.

The Cedars Rapids are situated about midway between the Coteau Rapids above, and the Cascade Rapids below. The former will break up heavy ice coming down stream from Lake St. Francis, so that the works will not suffer from the action of ice, and the latter provide an ample, easy and natural deep outlet for the tail water, so that no ice blockade will occur below the power house. The rise and fall are the same in head water and tail water, so that the total head is constant.

The average flow of the river is about 260,000 c.f.s., of which about 80,000 c.f.s. flowed naturally between Isle aux Vaches and Cedars Point. Of this, 56,000 c.f.s. will be used for power development purposes, the balance of 24,000 c.f.s. being diverted so as to flow south of Isle aux Vaches in the main channel of the river.

The low discharge from Lake Ontario during navigation season was in November, 1895, and was about 185,000 c.f.s. This would be augmented by water reaching the river below Lake Ontario, so that 190,000 c.f.s. may be taken as low-water flow in the river during navigation period. Of this, 8,000 c.f.s. flows in the south channel, 102,000 in the navigation channel between Grande Isle and Isle aux Vaches, and 80,000 c.f.s. be-

tween Isle aux Vaches and the north shore. The diversion of 24,000 c.f.s. of the latter amount into the navigation channel, 56,000 c.f.s. being taken for power purposes, will make the flow in the navigation channel 126,000 c.f.s. under maximum operating conditions. The experience of pilots shows that navigating conditions have been improved by the company's works.

The period of minimum flow corresponds with the low-water stage adopted which is equivalent to 9.5 ft. on the sill of former Lock 14 (now demolished) of the Beauharnois Canal at Valleyfield, but this condition only existed once for a few days in November, when all passenger traffic had ceased. Navigation ceased entirely on the 25th of the month.

The power available at Cedars Rapids under the above conditions is the equivalent of a flow of 56,000 c.f.s. under a head of 32 ft., *viz.*, 150,000 h.p. at the outgoing terminals of the power house. It should be noted that minimum conditions of river flow have been considered on account of navigation requirements, but that such minimum conditions only occur at long intervals, and then not during the navigation season, which is from about May 1st to November 1st in these rapids. The full amount of power will be available throughout the year, a condition unique in hydro-electric development.

One of the most important questions in water power development in Canada is the interference arising from ice in some form or other, and steps are necessary to prevent stoppages of the power plant.

If a river were entirely covered with ice, there would be no bad effects from anchor ice or from frazil. This condition cannot occur for the whole of the river above the Cedars Rapids, but it will occur in the section which would be apt to cause most trouble.

The construction of a dam or dyke between Isle aux Vaches and Point des Cedres, a distance of about 1,000 ft., creates a large pond or bay in which the velocity of the water is low, and this will freeze over in the early part of winter to a point well up to the shore. Surface ice will also form readily in the head race. These conditions will prevent the formation of anchor ice or frazil in the vicinity of the entrance to the canal, and the only frazil to be feared is that flowing down the river from open water above the rapids. This will be carried in the upper four or five feet of water, and before reaching Isle aux Vaches will be moving generally in the direction of the main channel, so that it will not tend to enter the upper bay. Though the velocity in the main channel between Isle aux Vaches and Iberville Islands, which has been increased somewhat by the diversion of water not used in the development, is considered sufficient to carry ice in that direction, some piers have been built between Isle aux Vaches and the north shore to ensure more positive results. No ice troubles were experienced during the mild winter of 1914-15, but to guard against future possibilities a deflecting structure is being built out from the north shore towards Isle aux Vaches to direct the course of ice coming from Coteau Rapids towards the main channel. Should any ice enter the upper bay it will tend to lodge in the northeast corner and can be flushed out through sluice gates provided in the main dyke. The water will be drawn into the head race nearly at right angles to the direction of flow, so that only small quantities of ice could possibly be carried down, and that chiefly late in the season, when it is in a condition least likely to cause trouble. A second set of sluice gates has been provided on the dyke at the lower end of the head race to allow further flushing of ice from the head race if necessary.

The solid ice from Lake St. Francis, much of which will come down in the spring, will be broken up in the Coteau Rapids and the various islands in mid-stream will act as breakwaters protecting the works against damage from ice.

I have every reason to believe that adequate protection has been provided against ice troubles.

The canal or head race has been excavated through Cedars Point, the Pointe du Moulin and a part of the river bed between these points. At the head of the rapids it has been excavated to the required depth throughout, whereas at the lower end at Pointe du Moulin it has been brought approximately to the level of the river bottom, giving a depth of about 35 ft. The cross-section is everywhere ample for the flow required at moderate speed.

The earth, boulders and rock excavated were used in the construction of the dyke, and sufficient material, clay mixed with boulders, was found in the cut to make a reliable, economical dam of very generous dimensions. The slopes are protected by rip-rap and no fear of erosion or damage by ice need be entertained. On the north side it was necessary to build a bank for some distance to form the head race, and to provide drainage for the land.

The power house is built across the lower end of the head race, and has its foundations on rock. The substructure is monolithic concrete, the building itself being a steel frame combined with concrete slabs built by the Unit Construction Company, as described already in a paper read before this Society by Mr. Conzelman on October 22, 1914.

The buildings and equipment have been designed so as to enable additions to be made as the business expands. Nine units, each of 10,500 h.p., have been installed, and a tenth is being completed. The turbines are single runners, set vertically, and are the largest units that have yet been used.

There were no special contingencies in connection with the construction, and continuity of work resulted.

The principal items of uncertainty in the cost of an hydraulic work are due to the nature of the foundations and the difficulty of unwatering. Over the whole site lies good limestone rock, overlaid with clay and boulders, and the materials were suited to the most exacting requirements. The unwatering, while on a large scale, was a simple operation. The natural material was left in place at the head of the canal to form a cofferdam, and a crib was built downstream on the outer line of the dyke to protect it during the early stages of construction.

ENGINEERS' CLUB OF TORONTO.

Following are the officers of the Engineers' Club of Toronto for the year 1917:—

President, E. L. Cousins, chief engineer of the Toronto Harbor Commission; first vice-president, L. V. Rorke, of the Ontario Government Survey Department; second vice-president, C. W. Power, of the Canadian Stewart Co.; third vice-president, J. R. W. Ambrose, chief engineer of the Toronto Terminal Railways Co.; secretary-treasurer, R. B. Wolsey; directors, H. G. Acres, W. A. Bucke, Alfred Burton, J. B. Carswell, A. G. Cumming, Arthur Hewitt, T. S. Young, Chas. H. Heys, Tracey D. LeMay, T. S. Stevens and M. P. White.

WINNIPEG AQUEDUCT EXCAVATION.

IN the January issue of The Excavating Engineer, a monthly paper published by interests associated with The Bucyrus Co., of South Milwaukee, Wis., appears an article by William Smaill, general superintendent of the Winnipeg Aqueduct Construction Co., Limited, showing the progress of excavation work on the Winnipeg Aqueduct. This article includes considerable general information of interest regarding the difficulties encountered and methods adopted in overcoming them. Through the courtesy of Bradlee van Brunt, editor of The Excavating Engineer, is printed the following abstract of the article and its illustrations:—

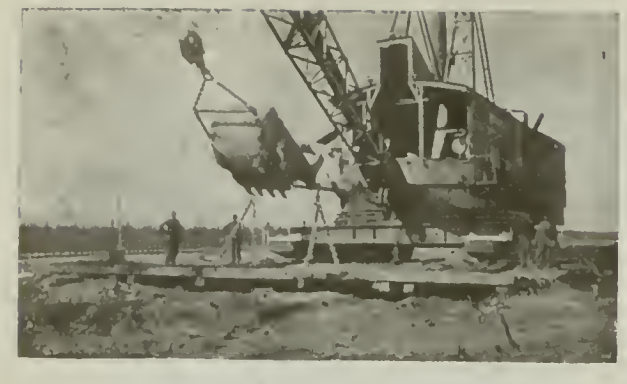
View of the Cleared Right-of-Way.
District railway track and pilot ditch at one side.

The Bucyrus draglines that are at work on the eastern end of the aqueduct, between Camps 1 and 5 of the aqueduct ditch proper, encounter nearly all kinds of soil. At Camp 4 there is about a three-mile stretch of hard pan. Last year this was loosened up with dynamite ahead of the dragline, but this year, after some experimenting, by giving the teeth a sharp narrow chisel point and considerable more rake than usual, the contractors have excavated through the hardpan without explosives. The bucket teeth in this hardpan require dressing every three or four days.

Handling Muskeg at Camp 6.—In Camp 6 the class-14 machine is in operation. This larger machine was purchased for places where the cuts ran from 12 to 17 feet in depth, in order that the necessary amount of daily lineal feet of progress could be maintained. This season the 60-foot boom was lengthened 10 feet in order to get a little longer reach. This machine had to go through a stretch of muskeg averaging about 15 feet deep. The excavation was handled by digging to such a depth that the sides would just hold up. This would probably average 5 to 7 feet. The dragline would excavate a stretch at this depth, then return and excavate the trench

Dragline Ready to Excavate.
Drainage ditch in foreground. Pilot ditch is on other side of the dragline. Between these two ditches is the core that is dug to the final excavation line.

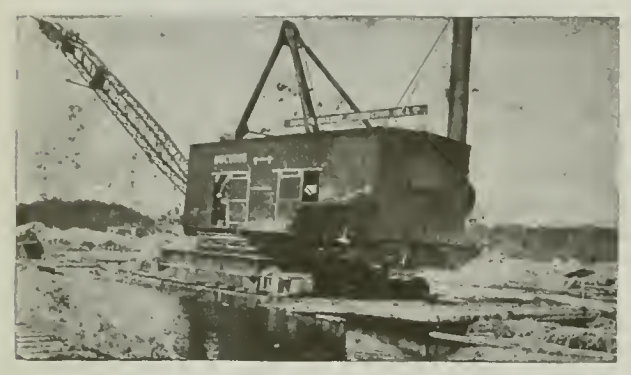
Excavation in Progress at Mile 30.
This view shows the depth of muskeg overlaying the sandy clay; also shows pilot ditch.



. Dragline Moving Into Position.
Placing pads, weighing over 7 tons each, ahead of itself.

a little deeper. Between cuts the sides of the cut would get a chance to drain and compact themselves a little more each time, and eventually the ditch could be excavated to grade. In most cases it took three to four cuts. In one stretch, owing to slides, mostly caused by heavy rains, the machine had to go over the ground eight times.

At Camp 7 two new class-7's, and one class-24 have



Crossing Falcon River on Cribbing.
The cribbing was made from wind logs that originally stuck about two feet out of the river. The machine is a class-20 Bucyrus.

been erected. The class-24 has a 10-foot boom and a 3½-yard bucket and is intended for work in the big cut where the top width of the trench will probably run as much as 90 feet, with a depth of 26 feet.

All three machines were erected close to the railway track at mile 89. The class-24 was moved across the 15-

Completed Aqueduct Before Backfilling.
View along the shore of Indian Bay. The intake is just over the rock ridge in the middle centre. The dike is holding out about 3½ feet of water that would otherwise float the surface.

foot pilot ditch which was dug with a small gasoline dredge the year before, and was started on a ditch about 70 feet top width, and 20 feet bottom width, with a depth varying from 16 to 20 feet.

The machine started on May 9th and has been working east. It was originally intended to place all the muskeg on the north and clay on the south side of the cut. On starting the excavation it was found that the heavy sandy clay would have to be deposited as far as possible from the sides of the trench, as material in the bottom of the cut was a rather soft clay, and any extra weight deposited near the edge of the cut would cause the bank to settle down and clay to raise up in the cut.

Backfilling.—First Operation.
Depositing sandy clay alongside the aqueduct.

For this reason all heavy material was placed away from the sides of the cut to the limit of boom reach. A small amount of light muskeg was placed on the edge of the cut at the south side, to make grade for concrete track and balance of muskeg was placed on north side. This method got rid of all slides with the exception of those caused by heavy rains. In one storm, six inches of rain fell during the night.

A couple of these slides were bad enough to make it necessary to move the dragline back in order to be able

General View of Machine Backfilling.
Sandy clay is placed alongside arch, filling in nearly to crown. Then a few feet of muskeg is placed, the whole being topped with sandy clay.

to dig them out. The class-7's were used to dig a continuous drainage ditch north of the dump on the north side of the cut, through the muskeg country, for the future protection of the work.

Work at Camp 8.—The class-20 was erected at Camp 8, on the shore of Indian Bay near the intake. This

machine has an 85-foot boom and 2½-yard bucket and is to work west towards the class-24, and on excavation where the cut does not exceed eighteen feet, and top width of trench, sixty-five feet. The first work it did was to cross a swampy arm of Indian Bay near the intake. The best bottom occurs near the edge of the water following the shore line. The machine started excavating April 20th. A shell of frost in the swamp materially aided in holding up the machine.

As excavation proceeded, the clay that came from the bottom of the cut was placed on the lake side of the cut to aid in preventing water from coming into the trench. Owing to heavy rains, the lake later rose to a height that would have brought three to four feet of water over the part where the trench was excavated, but by protecting this dyke with brush, etc., water was kept out and concreting was successfully placed.

On the west of the Falcon River the aqueduct follows along the shores of Snake Lake, a body of water lying in a muskeg bog, about three miles long, the muskeg being from five to fifteen feet deep. The extraordinary high

Backfilling.—Second Operation.
Depositing muskeg on top of the sandy clay.

water this summer raised this lake so that there was three to four feet of water over the line of the aqueduct, with most of the bog floating in the water.

To get through this, a small gasoline dredge was mounted on a scow, making a cut on the lake side of the aqueduct line, and depositing the spoil, making a dyke around an area, taking in about a quarter mile of aqueduct line at a time. This was pumped out, by means of centrifugal pumps, low enough to get the class-20 on the surface of the muskeg.

This machine deposited enough heavy spoil from the bottom of the trench on top of that placed by the dredge, to compress the muskeg sufficiently so that the trench could be pumped out and the aqueduct placed therein. About two miles of trench remain to be excavated on this stretch.

Machine-placed Backfill.—These draglines are now backfilling the concrete that was placed in the summer. The backfilling placed by machines had to be placed carefully so as not to cause any shock to the concrete structure, but the material spilling out of the bucket in a continuous stream, even from a small height, makes a much more homogeneous and compact mass than can be secured by any means of hand tamping.

At Camp 7 the scheme of placing spoil and replacing backfill, worked out exceptionally well. The difference between the machine and hand work was well illustrated here. The specifications for backfilling call for the first four feet to be hand-placed and hand-tamped, the balance

Backfilling at Indianhead Bay.
View between Falcon River and the intake. The material deposited directly over the arch is muskeg.

of the work not requiring tamping. A section two hundred feet long, which was hand-placed, was carefully inspected and observed. Later on, a section adjoining this was placed by machine, and after it had been allowed to settle for some weeks, the difference between the hand-placed and the machine-placed was very noticeable. The hand-placed backfill had settled badly, with a continuous deep crack over the centre of the arch, and other cracks on the sides, while the machine-placed backfill had settled very little and with practically no cracks.

The class-24 places the clay along the sides of the arch up to the crown, then takes the muskeg material (which makes a fine insulation medium) from the place

Backfilling.—Third Operation.
Placing sandy clay on top of the muskeg.

where the concrete track was located, placing it over the crown of the arch to a depth of two feet or more, and then covering the whole with the remainder of the sandy clay from the cut.

The electric furnaces already placed in the United States represent the utilization of 125,000 to 135,000 electrical horsepower. This means an output of about a million tons of ingots or castings per annum. The Heroult system represents some 70 per cent. of the total tonnage.

Railroads were introduced in Switzerland in 1844 with the construction of the Basle-St. Ludwig line. The Zurich-Baden line followed in 1847. By 1860 there were 1,000 kilometres (621 miles) of normal-gauge lines in use, and in 1912 their length reached 3,500 kilometres (2,175 miles).

WATER POWERS OF THE PRAIRIE PROVINCES

THE Dominion Government controls the water resources of the Prairie Provinces and, during the past three or four years, has been particularly active in investigating them. The Water Power Branch of the Department of the Interior administers the water powers which come under the jurisdiction of the Dominion Government. In the territory under its jurisdiction it has sent out field parties to investigate many of the water powers and to establish numerous gauging stations, where regular observations are taken. This branch has been in active operation since 1908, and, during the past three years, has covered most of the rivers in the southern portion of these provinces. Particular attention was paid to the Winnipeg River, in eastern Manitoba, and to the Bow River and adjacent basins on the Rocky Mountain slope.

The Irrigation Branch of the Department of the Interior has also been actively investigating the water resources in certain portions of these provinces. Field investigations and irrigation surveys of various characters had been carried on since 1894, but systematized investigation really began with the organization of the Irrigation Branch in 1908. The progress reports published annually contain general information respecting streams investigated, together with results of stream measurements, which have become a distinct feature of the work.

The southern or more settled portion of the Prairie Provinces is fairly well covered by the work of these two branches of the Department of the Interior. As the northern portion had not been investigated by any other organization, the Commission of Conservation undertook exploratory surveys of the principal rivers in this region. The rivers were traversed, generally, by canoe, the descent of the falls or rapids being levelled, flow measurements taken, and other details connected with the feasibility of development noted.

For the rivers further north, information was obtained from the reports of explorations made by the Geological Survey, the data being compiled from reports and maps of this branch and from the explorers' notes. In this region, generally speaking, the information available respecting the different rapids and falls is confined to a statement of the vertical descent, but, in many cases, the geological formation and distances from head to foot of the rapids are also given.

The southern portion of the Prairie Provinces may be divided into three sections, having widely different water-power characteristics:

1. The portion in the vicinity of Lake Winnipeg, in the east.
2. The more level portion in the centre.
3. The mountain and foothill country in the west.

In the first, or eastern portion, the Winnipeg River is the main feature. This river, with its drainage area of 53,500 square miles, has a well-regulated flow and affords numerous water powers of immense value. Two of the sites have already been developed and supply the city of Winnipeg with its electrical energy, while construction work on some of the other sites has either been commenced or is on the eve of starting. Numerous smaller streams in this eastern portion also afford splendid opportunities for water power development, some of them being actually utilized on the Minnedosa and Shell Rivers. This section also includes the Grand Rapids of the Saskatchewan River, where a head of 80 feet is available, affording an exceptionally good power site.

The second, or middle portion, is traversed by two main arteries, the North Saskatchewan and South Saskatchewan Rivers. These, with their main tributaries, flow with an even, moderate current with no concentrated descents of importance. Although, strictly speaking, this portion is not entirely without water powers, yet the possibilities of such are rather unfavorable. In almost every case the total head would have to be created and several proposed developments have already been abandoned on account of the high cost of development.

The third portion, of which the Bow River is typical, has many valuable water powers. There are none of unusual size, those on the Bow River itself probably being the most important. The slopes of the streams, characteristic of a mountainous region, are generally very steep, and, while the flow of water is subject to fairly large variation, good opportunities for storage and artificial regulation are afforded.

Among the special measures taken by the Dominion Government in connection with the administration of the water powers in the southern portion of the Prairie Provinces, may be mentioned the setting aside of the eastern slope of the Rocky Mountains as a forest reserve, known as the Rocky Mountains Forest Reserve. This step was taken on the recommendation of the Commission of Conservation, and, as a result, an area of 17,900 square miles has been assured protection from such denudation as has already taken place in some of the older provinces. All the upper tributaries of the North Saskatchewan and South Saskatchewan Rivers have their sources within this area, and the beneficial effect of conserving its forest cover is evident as far east as the Grand Rapid on the main Saskatchewan River. With a similar object in view, the Commission has recently recommended that steps be taken to segregate, as a forest reserve, the upper portion of the drainage area of the Winnipeg River. This recommendation will doubtless be acted upon shortly, and will prevent the useless dissipation of the present facilities which this district offers for storage and conservation of run-off. This step is of particular significance, as the Winnipeg River affords the only water powers of importance susceptible, under present conditions, of being economically developed and transmitted to the city of Winnipeg and the surrounding district, an area that will undoubtedly become thickly populated within a very few years.

Among other measures may be mentioned, also, the policy adopted by the Dominion Government, of reserving, on the recommendation of the superintendent of the Water Power Branch, all vacant Dominion lands which may be valuable for the development of water power. The land is thus held from the hands of speculators and kept for promoters of *bona fide* power development. Reservations of this character have already been made on the Winnipeg, Saskatchewan, Bow, Elbow, Athabaska, Peace and other rivers.

*Abstract from introduction to "Water Powers of Manitoba, Saskatchewan and Alberta," published by the Commission of Conservation.

Sir Adam Beck, in giving information relating to the Ontario Hydro-Electric System for the year ending October 31, 1916, says that the total average horsepower used in the system was 109,583, at an average cost of $9.10 per horsepower. The total receipts were $2,038,792. As regards the Severn system, the total expenses, including generating, amounted to $54,438, and the revenue to $94,694.

CANADA'S RAILWAY PROBLEM AND ITS SOLUTION.

By William Francis Tye, C.E.,
Formerly Chief Engineer, Canadian Pacific Railway Co.

(Concluded from last week's issue.)

Cost of Operation on the Intercolonial.—The Intercolonial is the most extensive public-owned system on the continent. As shown in the beginning of this paper, in the year 1913 (which was a very favorable one for the Intercolonial) it cost the owners of this road—the people of Canada—including interest on the cost, $25,832,136, to earn $12,349,296, while it cost the owners of the Canadian Pacific (the shareholders) $90,562,161 to earn $129,481,885, or, in other words, on the Intercolonial it cost $209 to do $100 worth of business, while on the Canadian Pacific it cost $70 to do $100 worth of business.

Freight Rates.—It is usually supposed that the low rates charged are responsible for this condition.

Let us see just how these rates do compare:—

The latest tariffs—both passenger and freight—show that on all business, not purely local, the rates are exactly the same. This is, of necessity, true, as such rates are fixed by competition, and not by the needs of a political party. The private-owned competing road, which is much shorter, or the water-carriers, set the through rates and the Intercolonial must follow.

The through rates per mile are undoubtedly much lower on the Intercolonial, but this is because it is so much longer, the distance from Montreal to St. John being 740 miles by the Intercolonial, and 480 miles by the Canadian Pacific Railway, and from Montreal to Moncton by the Intercolonial 651 miles and by the Canadian Pacific 572 miles.

In purely local and non-competitive business the freight tariffs show the class rates, as follows: As nearly as possible similar conditions and distances were selected so as to make a fair comparison.

MAIN LINE

Canadian Pacific—	Miles.	Basic Rate per 100 lbs.	Intercolonial—	Miles.	Basic Rate per 100 lbs.
St. John to:			St. John to:		
Grand Bay	9.9	10c.	Rothesay	8.5	10c.
Westfield	13.9	12c.	Quispamsis	12.0	12c.
Welsford	23.8	16c.	Hampton	22.0	16c.
Enniskillen	34.3	20c.	Apohaqui	39.3	20c.
Macadam	84.3	32c.	Moncton	89.3	30c.
	Miles.	Basic Rate per 100 lbs.		Miles.	Basic Rate per 100 lbs.
St. John to:			Moncton to:		
Megantic	329.0	54c.	St. Fabian	328.2	48c.
Sherbrooke	373.0	54c.	Tobin	349.9	48c.
Magog	393.4	58c.	Riviere Ouelle	408.6	54c.
Adirondack Jct.	472.7	58c.	Chaudiere	497.0	54c.
Foster	412.2	58c.	St. Nicholas	501.0	58c.
			St. Lambert	644.4	58c.
			Levis	488.4	54c.
			Drummondville	586.4	58c.

BRANCH LINE RATES

	Miles.	Basic Rate per 100 lbs.		Miles.	Basic Rate per 100 lbs.
McAdam to:			Truro to:		
Cottrell	6.6	10c.	Union	8.4	10c.
Benton	33.1	20c.	Hopwell	34.6	20c.
Newburg	55.3	26c.	Merigonish	56.1	24c.
Florenceville	74.9	30c.	James River	74.9	28c.
Aroostook	105.7	36c.	Lenwood	108.6	32c.
Grand Falls	124.8	36c.	Mulgrave	122.3	34c.
Edmundston	168.8	42c.	McKinnon	162.3	36c.

It will be seen that for distances up to about 35 miles, the rates are identical; for distances of 35 to 75 miles, C.P.R. rates are about 7½% higher than on the Intercolonial; from 100 to 125 miles they are about 12% higher; on distances of 165 miles 17% higher; on distances of 320 to 350 miles 12½% higher; on distances of 400 to 475 miles 7½% higher, or an average of about 10%.

The rates from St. John or Moncton to points in the same longitude, such as Levis on the Intercolonial, and Megantic on the Canadian Pacific; or to Drummondville on the Intercolonial, and Foster on the Canadian Pacific, are the same, though they are much less per mile on the Intercolonial, showing the very bad effect of the long uneconomical location of the Intercolonial as compared with the Canadian Pacific Railway.

In the commodity tariffs, the rates per mile quoted are exactly the same.

In the case of bituminous coal, of which the Intercolonial handles a large tonnage, the through rates are fixed by the water-borne traffic. In strictly local business, the Intercolonial rates from such points as Sydney are practically the same as Canadian Pacific rates on American coal from such points as Adirondack Junction up to a distance of about 100 miles. Beyond that distance the Canadian Pacific rates are higher in about the same proportion as in the class rates.

On cement, all of which originates on roads other than the Intercolonial, the rates from Montreal to all New Brunswick points are the same, on local business out of Montreal the Canadian Pacific rates per mile are the lower.

It thus appears that on all through or competitive business, on all business originating on or destined for other lines, the rates are fixed by agreement, and are the same. On all purely local business not affected by other competition, the Canadian Pacific rates per mile are apparently on an average about 10% higher, some portion of this being due to the uneconomical location of the Intercolonial.

Canadian Government Railway Statistics do not divide traffic between competitive and non-competitive, but they do show that in 1913, 36% of the traffic originated on other roads. When we add to this the amount destined to other roads, and that between competitive points, it seems a fair statement to make that at least 50% was competitive business, and, therefore, at the same rates as private companies gave.

In 1913 the freight earnings were $8,206,110
The total saving to the shippers would be 10% of half of this 410,305

The passenger tariffs show much the same conditions as the freight tariffs. Competitive business is at the same rates regardless of distance. Local rates per mile for short distances are practically the same, but gradually drop on the long round-about route via the north of New Brunswick, and as they approach the competitive points where the total rates must inevitably be the same.

As in the case of the freight tariffs, in strictly non-competitive local business, the Canadian Pacific passenger rates per mile appear to be on an average about 10% higher than those of the Intercolonial.

There is no way in which the amount of business effected can be ascertained, but it is believed it cannot be more than 50% of the total gross passenger earnings.

In 1913 the total gross passenger earnings amounted to	$4,037,531
The total saving to the travelling public would be 10% of half of this	201,687
Or a total saving for passengers and freight of	611,993
In 1915 the total saving would be	512,513

The results for 1913 and 1915 are thus:

1913.

Gross earnings	$12,349,296.00
Actual cost, including interest	25,832,136.00
Saving by lower rate	611,993.00
Net cost	25,220,143.00
Cost for each $100 earned	204.20

1915.

Gross earnings	$11,259,710.00
Actual cost, including interest	25,653,907.00
Saving by lower rate	512,513.00
Net cost	25,141,394.00
Cost per each $100 earned	220.60

The justification put forward for this remarkable state of affairs, is that the Intercolonial was built for political purposes to bring the Maritime Provinces into Confederation, and any attempt to make the road pay would be looked upon as breaking faith with the people of the Maritime Provinces, who look upon the Intercolonial as an offset to the canals in the Upper Provinces, which are operated without any tolls. It must not be forgotten that the Canadian Pacific, too, was built for a political purpose, to bring British Columbia into Confederation, and it has been as great a financial success under private management as the Intercolonial has been a failure under government management.

Whether the reasons advanced for the failure of the Intercolonial be sufficient or not, they certainly do not apply to the western roads, and there are no similar questions to complicate the problem of how best to dispose of the Transcontinental lines.

We have thus seen that both government construction and management have been extremely extravagant and wasteful. While Canada has been rich enough to stand such wasteful and extravagant methods, when applied to a small road like the Intercolonial, it could not possibly stand them when applied to the huge transcontinental systems.

Proposed Consolidation.—The remedy which the writer proposes for this state of affairs, and the only one which he believes has any hope of success, is to combine the Grand Trunk, Grand Trunk Pacific and National Transcontinental and Canadian Northern under one company.

Canada Should Follow Example Set by Sir John Macdonald.—Canada now stands at the parting of the ways, just as she did in 1879. The grave question then at issue was whether the Canadian Pacific should be constructed and managed by the government or by a private corporation. No one looking at the question can now fail to be struck by the wisdom displayed by the greatest of all Canadian statesmen, Sir John Macdonald, when he decided that the road should be turned over to a private corporation.

Can any sane person imagine for an instant that any government could have made anything like such a success as the company has made of the Canadian Pacific? The same question is at issue to-day. Shall we follow the wise example set by Sir John Macdonald, organize a new company composed of men of the best financial and practical ability, give them the necessary safeguards and allow them to develop another Canadian Pacific, or shall we turn the roads over to the government, knowing the wasteful and extravagant methods of the government construction and management, and develop another and vaster Intercolonial?

It should be no more difficult to get a private corporation of the very best class to take over our present roads, than it was for Sir John Macdonald. The present conditions are much more favorable. At that date neither the Canadian nor the American Northwest had been proved to be capable of supporting a large population. The only railways in the country north and west of St. Paul were a small portion of the Northern Pacific, which up to that time had proved to be a financial failure; the St. Paul & Pacific, some 400 miles in length, which only the year before had been taken out of the hands of the receivers and reorganized by Mr. Hill, under the name of the St. Paul, Minneapolis & Manitoba, and a few miles of the Canadian Pacific under construction west of Lake Superior.

Since that time the country has been occupied by such systems as the Northern Pacific, Great Northern, St. Paul, Minneapolis & Sault Ste. Marie, and the Canadian Pacific, among the most prosperous roads in the world; by thousands of miles of extensions of more southerly roads; by the Canadian Northern, prosperous as long as it remained a purely western road, and by the only failures to date, the National Transcontinental and Grand Trunk Pacific Railways, and they are failures as the result of a standard of construction far in advance of their needs, and the lack of feeders without which no road can succeed.

The part of Western Canada traversed by the proposed combination is equal to that traversed by any transcontinental road either in Canada or in the United States, and is decidedly superior to that traversed by most of them.

So far, Western Canada has hardly been scratched. In 1906 the whole grain output came from an acreage of less than 5% of the area within five miles of the Canadian Pacific lines, and at the present time it comes from an acreage of less than 10% of the arable land in the three Prairie Provinces. The writer does not see how there can be the faintest doubt as to the ultimate success of the proposed consolidation, if put into the hands of a strong private corporation, when one takes into consideration the character of the country, its similarity to the country traversed by the other successful American and Canadian railways, the continued and rapid increase in the traffic of the whole Canadian railway system, and the fact that most of the other roads, in the same or similar territory, have had similar troubles, and that they are now, in a very few years, among the most successful roads in the world.

Immediate Success Impossible.—The consolidation could not hope to be financially successful at first, as the net revenue could not possibly be sufficient to pay the fixed charges, and a series of deficits are sure to result. These deficits, I believe, would not extend over a period of more than eight or ten years at the most.

The necessary capital should be raised by an issue of common stock, with a guarantee of 5% interest for ten years by the Canadian government, the amount guaranteed being limited to, say, $200,000,000. The legislation constituting the company should be on the same lines as that which constituted the Canadian Pacific; that is, it should be an actual contract between the government and the company, setting forth in detail the respective rights

of each party. One of the clauses in this contract should be (as was in the Canadian Pacific contract) that until such time as the company was earning 10% on the actual cost to it of the road, equipment, etc., the government should have no right to regulate rates.

As the various governments, Dominion and provincial, have guaranteed most of the cost of the lines forming the proposed combination, they should be willing to agree to these terms, as if the company could not meet its fixed charges the government would have to meet them.

The situation has arisen owing to the unwise policy of duplication of lines, encouraged and bonused by the government, and to its extravagance in construction. If there is a penalty to be paid for the indulgence in this policy, the country must be the one to stand it. It is sure and certain, if the government nationalizes the roads and assumes the management, that the deficits will be many times as great as if the roads be operated by a private company, and in this event the deficits would have to be met by the government. Canada should be well satisfied to get out of this mess by paying deficits (is such there be) for a few years. It is quite in line with what we have been doing ever since Confederation, first of all, giving money and land, then money only, and lately, and worst of all, guaranteeing bonds for the construction of railways.

A new company sufficiently strong to finance such a consolidation should be formed to take them over. In this new company the government should have a 40% interest, should own 40% of the stock, furnish 40% of the money, have 40% of the directorate, should have an active voice in the policy, but should not have any say in the actual management of the road.

This would give the government a direct voice in the policy of the road; would enable it to mould its future, and would give all the benefits, without any of the evils, of government ownership

At present there is only one place—New York—where the bulk of the money for such an enterprise could be secured, but there seems to be no reason why at least 11% or 12% should not be raised by private capital in Canada. With 40% held by the government, and at least 11% or 12% by private Canadian capital, the actual control would be in Canadian hands.

If such a combination were made the roads should be connected in several places. The most important would be, as shown on the map, in Northern Ontario, at some point east of Lake Nepigon, probably from the north end of Long Lake on the Canadian Northern to a point near Titania on the Transcontinental. The map shows how this connecting would give the shortest and most direct route from Winnipeg to Montreal and Toronto. They would also have to be connected at the Yellowhead Pass, where they are side by side; at Montreal; at some point, say, Napanee, on the lines between Toronto and Ottawa, and, no doubt, at many points on the prairie.

Main Lines.—The main lines would then be: (As shown on accompanying map.)

Prince Rupert to Quebec and Moncton: Grand Trunk Pacific and National Transcontinental.

Vancouver to Montreal: Canadian Northern, Vancouver to Yellowhead Pass; Grand Trunk Pacific, Yellowhead Pass to Winnipeg; National Transcontinental, Winnipeg to Titania; new line to be built, Titania to Long Lake; and Canadian Northern, Long Lake to Montreal.

Toronto to Ottawa: Grand Trunk from Toronto to, say, Napanee, and Canadian Northern from Napanee to Ottawa. The various main lines of the Grand Trunk would remain the same.

Such a combination would have a first-class system in Ontario and the east, reaching every important centre; a main line to Chicago, with good local branches in Michigan; a main line to Portland (the natural winter port of Canada); the shortest line to St. John and Halifax (the two Canadian winter ports); a good connection with the New England States by way of the Central Vermont; a very good local system in the prairie provinces—Manitoba, Saskatchewan and Alberta—and, by far, the best line across the mountains connecting the Pacific ports with the prairie provinces.

Advantages of Consolidation.—There are many advantages which would be had from the consolidation, which cannot be had separately.

Main Line Distances Reduced.—The following table, giving the mileages from different points in the east to Winnipeg and Vancouver, shows how the distance could be reduced below similar distances on the individual roads, and how the new mileage would compare with the Canadian Pacific. In the case of St. John to Winnipeg, a new line down the St. John valley would be necessary to get the reduction in distance if such a connection were found to be desirable.

Railway	Montreal to Winnipeg	Toronto to Winnipeg	Quebec to Winnipeg	St. John to Winnipeg	Halifax to Winnipeg	Portland to Winnipeg
Can. Pac.	1,411.6	1,232.3	1,563.4	1,882.0	2,157.2	.....
Can. Nor.	1,455.7	1,312.5	1,607.5	.....	.....	.....
Grand Trk. Gr. Tr. Pac. Nat. Trans.	1,425.0	1,255.9	1,350.3	1,804.0	1,990.7	1,719.3
Prop. Consol.	1,347.7	1,204.5	1,350.3	1,804.2	1,990.7	1,645.0

	Winnipeg to Vancouver	Edmonton to Vancouver	Edmonton to Prince Rupert	Montreal to Vancouver	Toronto to Vancouver
Can. Pac.	1,483.5	840.5	....	2,895.1	2,715.8
Can. Nor.	1,599.7	....	....	3,055.4	2,912.2
Grand Trk. Gr. Tr. Pac. Nat. Trans.	1,760.6	967.7	953.2	3,185.6	3,016.6
Prop. Consol.	1,555.9	763.0	....	2,903.6	2,760.4

	Quebec to Vancouver
Can. Pac.	3,406.9
Can. Nor.	3,207.2
Grand Trk. Gr. Tr. Pac. Nat. Trans.	3,110.9
Prop. Consol.	2,906.2

Thus the distance from Montreal to Winnipeg would be 64 miles shorter than by the Canadian Pacific, 108 miles shorter than by the present Canadian Northern and 78 miles shorter than by the present Grand Trunk connection.

From Toronto to Winnipeg the new route would be 28 miles shorter than by the Canadian Pacific, 108 miles shorter than by the present Canadian Northern and 51 miles shorter than by the present Grand Trunk connection.

From Winnipeg to Vancouver the new route would be 44 miles shorter than by the present Canadian Northern, 205 miles shorter than the proposed Grand Trunk connection and only 72 miles longer than the Canadian Pacific. For winter haul of wheat it would have a decided advantage over the Canadian Pacific as the distance from Winnipeg to St. John would be 78 miles shorter and to Halifax 167 miles shorter than by that road, and the haul would be 237 miles shorter, by the new consolidation, from Winnipeg to Portland than from Winnipeg to St. John by the Canadian Pacific. It would also decidedly improve the Grand Trunk Pacific

connection between the prairie provinces and the Pacific, as the distance between Edmonton and Vancouver would be 190 miles shorter than the distance from Edmonton to Prince Rupert.

Main Line Grades.—The grades on the main lines of the new consolidation from Montreal, Toronto and Quebec to Winnipeg and Vancouver would be truly remarkable for such a length of line, and one through so many hundreds of miles of mountains. From Edmonton to Montreal, Toronto and Quebec, there would be no grades steeper than 0.4% against eastbound and 0.6% against westbound traffic. From Edmonton to Vancouver there would be no grades steeper than 0.7% against the eastbound and 0.4% against westbound traffic.

The main lines, as now constructed, have many miles of 1% grades, or steeper.

The Grand Trunk from Montreal and Toronto to Cochrane has grades of 1% or steeper against both eastbound and westbound traffic.

The main line of the Canadian Northern in Manitoba, Saskatchewan and Alberta, and from Port Arthur to Winnipeg, has many grades of 1% or steeper against both eastbound and westbound traffic.

The Canadian Pacific has, on its main line between Montreal and Fort William, in Alberta, and from the Columbia River to Vancouver, many grades of 1% and steeper against both eastbound and westbound traffic, and in the Rocky and Selkirk Mountains many miles of 2.2% grades against both eastbound and westbound traffic.

Thus the new consolidation would have the shortest line, and the best grades from all such points as Halifax, St. John, Portland, Quebec, Montreal and Toronto to Winnipeg.

It would also have a shorter line, with much better grades, than either the present Grand Trunk or Canadian Northern between Winnipeg and Vancouver, and while the Canadian Pacific would be eight miles shorter from Montreal to Vancouver, and 45 miles shorter from Toronto to Vancouver, the new route would have decidedly better grades, no snowslides, much less rise and fall, and would require less train-miles in its operation.

Less Cost to Complete.—The National Transcontinental and Grand Trunk Pacific, as now built, consists of a main line of 3,550 miles long, with only about 1,200 miles of branches.

MONTREAL AQUEDUCT COMMISSION.

Montreal's Board of Control has outlined the information that it expects from the St. Laurent-McRae-Vautelet Commission which will investigate the aqueduct scheme. The following resolution has been adopted by the Board, upon motion of Controller Villeneuve:—

That for the purpose of obtaining from experts a report on the value, as a whole, of the enlargement of the aqueduct for the development and municipalization of motive power, and in order to avoid all misunderstanding and controversy in the future, these gentlemen be asked to state clearly and firmly, their opinion as experts in the form of answers to the following questions, which they may add to whatever expression of personal opinion they deem expedient and interesting to make:—

(*a*) What is the value of the capital cost of the first enterprise, chargeable (that is, the total capital engaged plus the interest accumulated during the ten years that this undertaking has been under way, as well as interest that may accrue until completion) to the installation, as it will be when fully completed and in course of operation:

1—For the production of hydraulic motive power.

2—For pumping 100,000,000 gallons per 24 hours.

3—For electric lighting of all the city (distribution and lighting).

(*b*) The same question, under the same three heads, regarding annual operating cost, including financial charges for interest, sinking fund, depreciation, etc.

(*c*) To establish by a comparison of the respective figures for the cost of the first enterprise and annual operating cost, the advantage or disadvantage (pecuniary profit or loss) to the municipal treasury, by continuing to full completion this undertaking of the development of the aqueduct under present conditions of the project in course of execution. The comparison should be made showing respectively each item, for each of the following alternative propositions:—

1.—Present project of municipalization, continued as a whole up to the point of service and operation.

2.—Present conditions of annual cost of pumping by steam (low-level station) and by electricity (high-level station) of yearly lighting of the whole city by virtue of the contract in force with the companies. Taking into account the relative capacities of pumping and lighting between the conditions and needs of the present and those which are claimed will be realized by the project under way.

3.—An hypothesis of a central steam plant, assuring at the same time pumping and lighting, on the basis of modern operation and installation, with the respective yield and capacity of the project in course of execution—in a word, the substitution of steam for hydraulic power.

4.—Pumping assured, purely and simply, by acquiring power from one of the companies which produce it. The present low-level station being in this hypothesis, utilized as much as possible by the judicious adaptation of the existing turbine pumps, and by merely substituting the motors, the cost of operation to be at the expense of the city. In which the lighting will remain, as at present, supplied and ensured by a company.

(*d*) A table, giving for an average year, the yield minimum minimorium, month by month, in kilowatts, of the development of the aqueduct in course of construction.

(*e*) A statement of the effect of frazil ice on the production of hydraulic power under conditions existing at the site of the project under discussion, taking into consideration the difficulties experienced by other power development companies in the district contiguous thereto, and what difficulties may be reasonably looked for from ice conditions based on the actual experience of a number of years past.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

A general section meeting was held at the Society's rooms, Montreal, Thursday evening, February 8th. Col. Arthur Mignault, M.D., formerly in charge of the Laval University Hospital Unit, addressed the meeting, relating some experiences at the Front. The paper by G. W. Craig, city engineer, and J. F. Greene, bridge engineer, both of Calgary, on the construction of the Calgary Centre Street Bridge, which paper was presented to the Society at the meeting on January 9th, was read and discussed.

NITROGEN FROM SEWAGE.*

By Dr. S. Rideal, F.I.C., F.C.S.

Copeland, at Milwaukee, has recently discussed the question, "Is the Recovery of Nitrogen in Sewage Sludge Practicable?" and shows the nitrogen changes of Milwaukee city sewage by Imhoff and activated treatment as follows:—

		Parts per 1,000,000. Sewage.	Imhoff effluent.	Activated effluent.
August	N as	14.6	16.2	3.8
September	NH_3	13.5	15.4	5.7
		14.0	15.8	4.7
August	N as	.13	.13	6.0
September	N_2O_5	.14	.09	5.01
		.135	.11	5.5
August	N as	29	27	6
September	Organic	29	27	9
		29	27	7.5

At Milwaukee 0.25 cub. ft. of air per minute per square foot of tank surface, with a period of four hours' aeration with a sludge content of 25 per cent., is being adopted.

We see that (these are parts per 1,000,000, but, as American sewage is ten times weaker than English, the foregoing figures are comparable with ours at part per 100,000) the Imhoff effluent is very similar to the raw sewage, but that the activated effluent has more than half its ammonia oxidized, while only 25 per cent. of the organic nitrogen is retained. The sludge is richer in organic nitrogen by this latter amount, but some of the ammonia—about 5 parts—must be removed by the air.

If air be passed through the sewage or the Imhoff effluent without nitrification taking place, 10 parts per 1,000,000 of ammoniacal nitrogen should be present in it. Experiments are required to ascertain the conditions which have prevented the removal by the air of the residual 4.7 parts of ammonia in the activated sludge working.

Its subsequent recovery as sulphate of ammonia should present no difficulty, as the absorption of gaseous ammonia from the exhaust air by sulphuric acid is common practice in gasworks.

Mr. Copeland points out that the organic nitrogen of the original sewage passes away in the effluent from the Imhoff tank, but is retained by the activated treatment in its sludge.

This sludge is, therefore, the richest in nitrogen, and has the greatest manurial value. From the point of view we are now discussing, there is little possibility by any of the known processes of converting the organic nitrogen of sewage directly into ammonia or nitric acid in a form available for explosive manufactures, except destructive distillation.

Dried activated sludge (with 10 per cent. moisture) contains, according to Copeland, 5 to 9 per cent. of nitrogen, and such a sludge if retorted should give higher yields of ammoniacal liquor than are obtained in gasworks from ordinary coal.

Nitrates from Effluents.—My last suggestion deals with the recovery of nitrates from effluents.

The American weak sewage gave us 5 parts per 1,000,000 of nitric nitrogen in the activated effluent. In England our best bacterial beds give us up to 10 parts per 100,000.

In 1898 I made my first analyses of a camp effluent, that from the Caterham Barracks, where we then had a raw sewage with 17.2 parts of total nitrogen, and after a very efficient filter (put in by one of your past-presidents, Mr. Moncrieff) I found over 50 per cent., viz., 9.0 parts of nitric nitrogen in the effluent. There were still 5.0 parts of unoxidized ammonia, and this could easily be oxidized, making 14.0 parts of nitric nitrogen, or 14 lbs. per 10,000 gallons, equivalent to 85 lbs. of nitrate of soda per 10,000 gallons.

The natural concentration of sodium nitrate solutions in Chili might give us suggestions for the evaporation of this large volume of water. A filter-bed with no effluent drain protected from rainfall, if irrigated with such an effluent, would gradually concentrate the nitrate, and this season at each works we could ascertain the rate of evaporation under our climatic conditions.

If in a cucumber frame, 6 ft. by 4½ ft., 3 gallons could be evaporated per day, the earth at the end of a year would contain 9.3 lbs. of nitrate of soda. Drying sheds can also be heated by waste steam from the destructors, and a few degrees is often sufficient to raise the temperature above the wet bulb and thus ensure constant evaporation, even on days when the air is saturated.

America, although not fighting, has grappled with the problem this year, and is determined to create her own nitrate supply. I understand the Government have granted $20,000,000 towards founding the new industry.

*Abstract of paper read before the Association of Managers of Sewage Disposal Works.

T. R. DEACON ADDRESSES MANITOBA BRANCH OF CANADIAN SOCIETY OF CIVIL ENGINEERS

"A View of Necessary Action for After-the-War Conditions," was the subject of an address by T. R. Deacon, C.E., ex-mayor of Winnipeg and manager of the Manitoba Bridge & Iron Works, delivered before the regular February meeting of the Manitoba Branch of the Canadian Society of Civil Engineers.

Mr. Deacon pointed out the necessity for action to meet the conditions in Canada arising from the war. He believed that in the solving of a great number of problems, and in carrying out the industrial work after the war, the engineers would have a very considerable part. That there would be a large demand for engineers would be due to the work which of necessity must be carried forward to utilize the energy represented by the 400,000 men now in the army and 80,000 to 100,000 men engaged in munitions and kindred work.

In brief, said Mr. Deacon, the problems Canada must face at the close of the war are:—

1. Payment on a national debt which will probably amount to $5,000,000,000.
2. An annual pension fund.
3. The utilization of some 80,000 to 100,000 men at present engaged on munitions and kindred employment, who will be immediately thrown out of work on the cessation of hostilities.
4. The return of some 400,000 men from the front, comprising some of the best blood and energy of the country.

If these 500,000 men engaged in the war or in industries arising from the war, are to be retained in the country and given work in order to prevent their emigration to the United States, a comprehensive program should be undertaken by the government. That the work must be of a manufacturing or an industrial nature did not require proof, as it would require the wildest stretch of imagination to believe that these men will turn to pioneer farm work when manufacturing and industrial work would be available south of the Canadian boundary.

In place of allowing the raw products of the soil, forest, fisheries and mines to be exported from the country, Mr. Deacon believed that it is not only practicable but assuredly possible to provide industrial work which would utilize these raw materials, and which in turn would not only utilize the energy of these 500,000 men but would also help materially towards reducing and meeting the payments on the national debt.

The most feasible method of utilizing each of the natural resources appeared to him to be to copy the German plan of state co-operation with the manufacturers. That there would be many difficulties and many obstacles in the working out of such a scheme he admitted, but believed it was the most practicable method of meeting the conditions.

COMING MEETINGS.

MID-WEST CEMENT USERS' ASSOCIATION. Annual convention, Omaha, Neb., March 6-10, 1917. Frank Whipperman, secretary, 28th Avenue and Sahler Street, Omaha.

CANADIAN MINING INSTITUTE. Annual meeting in Montreal, March 7-9 at the Ritz-Carlton Hotel. Secretary, H. Mortimer Lamb, Ritz-Carlton Hotel, Montreal.

DIXIE HIGHWAY exposition and convention at Cincinnati, Ohio, May, 1917.

AMERICAN WATERWORKS ASSOCIATION. Thirty-seventh annual convention, "The Jefferson," Richmond, Va., May 7-11, 1917. President, Leonard Metcalf.

THE SOUTHWESTERN WATERWORKS ASSOCIATION. Annual convention at Topeka, Kan., June 11-14, 1917. Information from E. L. Fulkerson, Waco, Texas.

Manitoba's total railway mileage at the end of 1916 was 4,672.52, according to the annual report of the Provincial Department of Railways. The report says that notwithstanding the scarcity of labor, satisfactory progress has been made during the year on the Hudson's Bay Railway. Track has been laid to the Kettle Rapids, on the Nelson River, 330 miles from The Pas. It is intimated that the whole line, including all bridges, will be completed and ready for traffic by the end of 1917.

Electrically operated excavators are being used on a large drainage scheme in Idaho, U.S.A. Energy is obtained at a pressure of 44,000 volts from an overhead line; the average power consumed is 0.88 kilowatt-hour per cubic yard of material excavated, varying with the material excavated, being as low as 0.39 kilowatt-hour in light sandy loam, including all line and transformer losses

The Department of Trade and Commerce, Ottawa, has received information from Petrograd, Russia, to the effect that the Murman Railway, from Petrograd, to the ice-free port of Alexandrovsk, on the Arctic Ocean, has been completed. The road is of great importance for the import of munitions. The line, nearly 700 miles long, has been constructed in the face of most formidable engineering difficulties owing to the swamps and other features of the country, and has been completed before the anticipated time.

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses:—

434. Galvanized steel wire ropes.—A Buenos Aires firm of importers require f.o.b. New York prices on 56 coils of galvanized special flexible patent improved steel wire ropes with one main and six auxiliary hemp hearts. Specifications may be had on application to the Department of Trade and Commerce, Ottawa.

435. Hardware.—A firm distributing hardware in Western Siberia are open to receive quotations, if possible c.i.f. Vladivostok, from Canadian manufacturers of various kinds of hardware with a view to the execution of trial orders.

438. Street Cars.—An Italian street railway wishes to secure in Canada rolling stock for an extension of its line as follows: Four carriages with motors, 10 goods cars, 3 third-class cars, 3 first-class cars. Specifications are as follows: Motor carriages: Four motors; 70 horse-power; 1,650 volts, continuous current, Westinghouse brake with hand-brake, brakeman's compartment at end, height buffers 855 centimetres, width of motors 95 centimetres, multiple system Sprech at 800. Goods wagons or flat cars to carry ten tons, low sides to carry sand, etc. Passenger cars with 40 places, of which 14 should be at ends (7 at each end); distance between axles, 4.000 centimetres; length of frame, 9.770 centimetres; total length with buffers, 10.770 centimetres; width, 2 metres 20 centimetres. Electric motors must be able to pull 50 tons weight on grades of 60; 1,000 weight of the wire is 9 metres, falling to 4.20 metres where passing under bridges. Speed of motors up to 50 kilometers per hour. Speed of train is usually up to 30 kilometres. Cars must be able to go round a curve of 50 metres, radium.

440. Supplies for Siberia.—The New York office of a firm distributing goods throughout Western Siberia is desirous of receiving quotations from Canadian manufacturers of articles suitable for this market.

444. Steel Shafting.—A manufacturers' agent prominently connected with and favorably known to the wholesale trade of St. John's desires to be put in touch with Canadian manufacturers of cold-rolled steel shafting.

445. Steel Bars.—Canadian exporters of iron and steel bars are asked to communicate with a Newfoundland inquirer.

446. Copper Wire.—A Newfoundland inquirer desires to purchase Canadian copper wire—r.c. and bare.

447. Iron Pipe.—A Newfoundland importer asks for Canadian manufacturers of iron drain-pipe, 2-inch and 4-inch.

NEW INCORPORATIONS.

New Carlisle, Que.—The New Richmond Mining Company, $200,000. J. F. Marcotte, F. Marcotte, F. Blois.

Sherbrooke, Que.—The Dominion Metal Company, Limited, $20,000. N. B. Pritchard, H. Irwin, G. E. Borlase.

Windsor, Ont.—Bolton Mining Company, Limited, $500,000. E. J. Robinet, C. Robinet, L. Robinet.

Montreal, Que. — Hygienic Construction Corporation, Limited, $25,000. P. Richer, R. Lanctot, A. Savard; Montreal-East Construction Company, Limited, $40,000. T. K. Walton, C. H. Waugh, C. J. Kirlin; the Mack Brick Company, Limited, $500,000. R. T. Heneker, H. N. Chauvin, H. E. Walker.

Stanley, B.C.—Cariboo Chisholm Creek Mining Company, Limited, $300,000.

New Westminster, B.C.—Marsh, Bourne, Powers Contracting Company, Limited, $45,000.

Kamloops, B.C. — Branch Ranch Mines, Limited, $100,000.

Vancouver, B.C.—Texada Mines, Limited, $10,000; the Deeks Gravel and Rock Company, Limited, $10,000; the Lone Star Mining and Milling Company, Limited, $1,000,000.

Editorial

MORE CANADIAN REFINERIES NEEDED.

Canada, and the whole British Empire, would be strengthened industrially and martially by the establishment of more refineries and metallurgical plants within the Dominion, so that Canadian ores can be utilized without the aid of foreign refineries. This is one of the most important steps required in meeting after-the-war problems. It is to be hoped that the Dominion Government will help to establish more Canadian refineries at once. Careful inquiry should be instituted to reveal the best form in which such help can be given, whether by legislation forbidding exports of unrefined ores, or by bonuses or loans to refineries. The views or ore-producers, managers of existing refineries, owners of undeveloped ore properties, metal merchants and consumers, and bankers should be obtained by the government without further delay. A good start has been made in the policy adopted toward nickel refining in Ontario, but this policy should be extended to other ore resources and to other provinces.

The mining committee of the Vancouver Board of Trade has submitted a resolution to the government asking for legislation that will assist in the treatment of the many mineral products in which that province is so rich. The assistance should be given at as early a date as possible consistent with judicious enquiry as to whether the aid can best be rendered in the form of legislation.

British Columbia now refines but a small portion of the ores that could be produced from that province were adequate metallurgical works built to aid development. The present annual production of British Columbia lead is about 32,000 tons, most of which is refined at Trail, but the Vancouver committee states that there are important deposits of lead ores on the coast and along the route of the Grand Trunk Pacific which cannot be treated economically for want of smelting accommodation on the coast.

The copper production of British Columbia will soon be about 70,000 tons per annum. There are only two small copper refineries in the province, and at the present time six-sevenths of the copper produced must be shipped to foreign refineries.

About 5,000 tons of zinc ore are mined each year in British Columbia in excess of the present refinery capacity, and there are important zinc deposits on the coast and tributary to the Grand Trunk Pacific Railway which could be developed were spelter refining works available. Such plants could also handle Australian and other imported zinc ores, of which about 15,000 tons recently passed through the port of Vancouver en route to foreign spelter works.

Among the other metals which can be produced in British Columbia in greater quantities were adequate facilities provided for their treatment, are antimony, chrome, iron, mercury and molybdenum.

The Vancouver committee, which has rendered a public service in calling the attention of the government to these important facts, also suggests that an investigation be made of the refractory earth and clay deposits available for the manufacture of retorts suitable to the Belgian process for zinc ores not adapted to electro-chemical processes.

The essential requisite for most of these refineries, however, is cheap hydro-electric power, which is abundantly available in British Columbia. There are a number of hydro-electric plants already in operation in that province which cannot find a suitable market for all of the energy that they can readily produce, and the establishment of more refineries would do much toward placing some of these companies upon a more profitable basis, and would also mean the early development of more water powers.

RE THAT SWAIN DISCUSSION.

In a letter concerning the appointment of Prof. Swain to the Railway Board of Inquiry, a correspondent refers to "an interview with Sir Henry Drayton which you got and which was published on page 239 of your issue of September 21st, 1916."

Upon referring to the interview above mentioned, we regret extremely to note a serious error in the printing of that "interview," *viz.*, that we overlooked stating the fact that the interview had not been obtained from Sir Henry Drayton by *The Canadian Engineer*, and that it was merely a reprint of an interview which Sir Henry Drayton had given out to the Canadian press and which had been previously published in the daily newspapers.

The interview published in *The Canadian Engineer* was copied verbatim from The Toronto Globe of Wednesday, September 13th, 1916, and The Toronto Telegram of Tuesday, September 12th. *The Canadian Engineer* had not been in touch in any manner with Sir Henry Drayton or any other person regarding this appointment. The oversight in not crediting the above "interview" to the Toronto newspapers has evidently led to one or two misunderstandings which we trust this explanation will rectify.

FLAT-SLAB CONSTRUCTION.

The collapse of a flat-slab reinforced concrete building in the recent Quaker Oats fire at Peterborough, caused many engineers to question the fire-resisting qualities of that type of construction. The flat-slab type was first officially recognized in a building code by Chicago only as recently as 1914, so that, while it was claimed to be as fireproof as any other type of construction, the Peterborough fire caused some apprehension.

As thirteen flat-slab buildings (with a total permit value of $1,872,000) had been erected or started in Toronto during the past year, T. D. Mylrea, assistant city architect of Toronto, made a thorough investigation into the causes of the Peterborough collapse.

Mr. Mylrea found that it would be easier to explain why the Quaker Oats warehouse fell than why the Edison buildings stood. Evidence showed that temperatures of over 2,000° F. had penetrated two inches of concrete, and that the working strength of the steel had been reduced by about 80%. "In the columns this would not be of such grave importance as in the floor slabs," says Mr. Mylrea, "but it is probable that the floors failed first and carried the columns with them. It is possible that the depth of the beams and girders and the short spans of the floor

slabs in the Edison buildings offered a more effective resistance to collapse, even were the working strengths temporarily reduced."

Mr. Mylrea concludes that it would be incorrect to demand excessive fireproofing simply because one building collapsed under unusual fire conditions. "If a fire is of sufficient intensity and duration to heat a nine-inch floor slab through," he says, "it is evident that even four and one-half inches of fireproofing would have availed nothing. * * * The wiser course would be to have just such an amount of fireproofing as would prevent the steel from being overheated in an ordinary blaze."

The newspaper reports of the fire and the views of the insurance companies' engineers and inspectors confirm Mr. Mylrea's opinion that the Peterborough fire was unusually severe, so there would seem to be no reason for considering it a sign of any deficiency in the flat-slab type of construction.

PERSONAL.

J. W. ADAMS has been re-appointed acting city engineer of Chatham, Ont.

A. R. McVICAR, of Brantford, Ont., has been appointed county roads superintendent for Brant County.

E. W. MOORE, of Cleveland, Ohio, has been elected president of the Street Railway Company, London, Ont. Mr. Moore is a former Londoner.

Lieut. COULSON N. MITCHELL, Jr., a 1912 engineering graduate of Manitoba University, was recently awarded the Military Cross for bravery in action.

R. W. MacINTYRE, of Victoria, B.C., has been appointed supervising engineer of construction work now being done on the Pacific Great Eastern Railway.

JOHN H. BUNTING, who for the last four years has been joint manager of Bruce Peebles & Co. Limited, Edinburgh, Scotland, has been appointed general manager of the company.

W. G. MURRIN, who since April, 1913, has been acting as general superintendent of the British Columbia Electric Railway, with headquarters at Vancouver, is now assistant to the general manager, George Kidd.

THOS. TAYLOR, designing engineer of the Bloor Street Viaduct, Toronto, gave an address before the Engineers' Club of Toronto last evening on the design and construction of the viaduct. His remarks were illustrated by lantern slides. Mr. Taylor's address was supplemented by remarks by other engineers connected with the work.

Major HAROLD L. TROTTER, formerly a partner in the Henry Holgate firm of consulting engineers, Montreal, is in command of a field company, Canadian Engineers, and has been in action at the Somme. Major Trotter graduated with honors in 1903 at the Royal Military College. He is a son of Col. W. C. Trotter, president and general manager of the Standard Clay Products Co., Limited, St. Johns, P.Q.

Another son of Col. Trotter, Major CLIFFORD T. TROTTER, is also at the Somme. At the outbreak of war he was engineer in charge of construction at the Standard Clay Products plants at New Glasgow, N.S., having designed and built the company's large sewer pipe factory at that place. He graduated at the Royal Military College in 1907 and later received the degree of B.Sc. at McGill University. He went overseas as a captain in March, 1915, and after being engaged in severe fighting on the Ypres salient was mentioned in despatches by Sir Douglas Haig and was promoted to be senior major of a division of engineers, having command of a field company.

OBITUARY.

J. G. TAYLOR, general superintendent of the C.P.R. for Saskatchewan from 1912 to 1916, died recently in Edmonton, aged 55.

JOHN JOYCE, one of the founders of the Shawinigan Water and Power Company, died at his home in Boston recently. Mr. Joyce was a director of the company for many years.

Lieut. J. W. BOYD, formerly employed as an engineer by the Toronto Harbor Commission, has died of wounds received in active service. Lieut. Boyd was born in Stratford, Ont., and educated in Toronto.

J. G. MACKLIN, M.Can.Soc.C.E., who six years ago left Canada to reside in England, failing health obliging him to seek a milder climate, died on February 5th. An Englishman by birth and education, Mr. Macklin came to Canada as a young man, and began his professional career in association with the late Col. Sir Casimir Gzowski, of Toronto, on the construction of the cantilever bridge spanning the Niagara River. Later he was employed by the Grand Trunk Railway Co. in building a branch line between Ottawa and Prescott, his headquarters being then at Ottawa. Subsequently, he organized the Midland Division of the Grand Trunk Railway and resided in Peterborough as chief engineer of that division for many years. The last important work on which he was engaged was the planning and construction of the dam in connection with the power plant on the Richelieu River, at Chambly, P.Q. Mr. Macklin was a member of the Canadian Society of Civil Engineers from its inception. He is survived by his widow, a daughter and a son, 1st Lieut. F. C. A. Macklin, Royal Engineers.

WILLIAM LYON MACKENZIE, bridge engineer for the Canadian Northern Railway, died at his home in Winnipeg on February 8th, aged 57 years. Mr. Mackenzie formerly was connected with the C.P.R. and Grand Trunk Railways in an engineering capacity and for twelve years had charge of all bridges on the Canadian Northern from Lake Superior west. He was a native of the township of South Dumfries, South Waterloo, Ont., and after attending Galt Collegiate Institute he was graduated as a civil engineer at Toronto, since which time he had a large and varied experience in railroad location and construction work. The first work to engage his attention was the building of the Canadian Pacific Railway from Toronto west through Galt and Woodstock and eastward via Peterborough to Smith's Falls, also the main line through North Bay. His services with the Canadian Pacific terminated with the completion of the Crow's Nest branch in 1899, when he joined the engineering staff of the Canadian Northern Railway. Mr. Mackenzie was a member of the Canadian Society of Civil Engineers, and 1917 chairman of the Manitoba branch. He formerly made his home in Galt, Ont., where his family resided for some years before moving west about ten years ago. He is survived by his widow, one son and two daughters.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

QUAKER OATS FIRE WRECKS FLAT-SLAB WAREHOUSE

T. D. MYLREA, ASSISTANT TO THE CITY ARCHITECT OF TORONTO, INVESTIGATES COLLAPSE OF REINFORCED CONCRETE BUILDING AT PETERBOROUGH AND REPORTS THAT STRUCTURE IS COMPLETELY RUINED OWING TO EXTREMELY HIGH TEMPERATURES MAINTAINED FOR UNUSUAL PERIOD—CITY ARCHITECT SAYS IMPOSSIBLE FOR ANY MATERIAL TO RESIST FIRE OF SUCH INTENSITY AND DURATION

T. D. MYLREA, engineer in charge of tests for the city architect's department, Toronto, has made a report on the destruction of the flat-slab type, reinforced concrete warehouse at the Quaker Oats fire, which occurred December 11th, 1916, at Peterborough, Ont.

As thirteen buildings of the flat-slab type were erected or started in Toronto during 1916 (with a permit value of $1,872,000), W. W. Pearse, the city architect and superintendent of building, was naturally anxious regarding the fireproof qualities of the flat-slab type of construction, in case any serious deficiency in that type of construction should have been shown by the Peterborough fire. Mr. Pearse states the flat slab type of construction was recognized in a building by-law by the city of Chicago in 1914, which was the first time that type of construction had been officially recognized in any city by-law, so far as he is aware. The fact that this recognition was so recent, increased Mr. Pearse's anxiety to know the full facts in regard to the failure at Peterborough, which was undoubtedly the worst of its kind in the history of reinforced concrete construction, and the first in the history of this particular type of reinforced concrete design.

Fig. 1—General View of Quaker Oats Plant Before Fire.

Mr. Mylrea's report, which is thorough and exhaustive, and which is accompanied by a number of plates and fifty-two photographs, proves conclusively that the Peterborough fire was a most unusual one, presenting conditions not likely to be duplicated very often, *viz.*:—

(1) The fire raged simultaneously on all seven floors (including basement) of the building.

(2) The oats and feed, which were piled high on each floor, burned fiercely but slowly, retaining a very high heat for a long period. They produced the effect of an intense coke fire.

(3) The fire raged in full blast for seven hours before any part of the building fell.

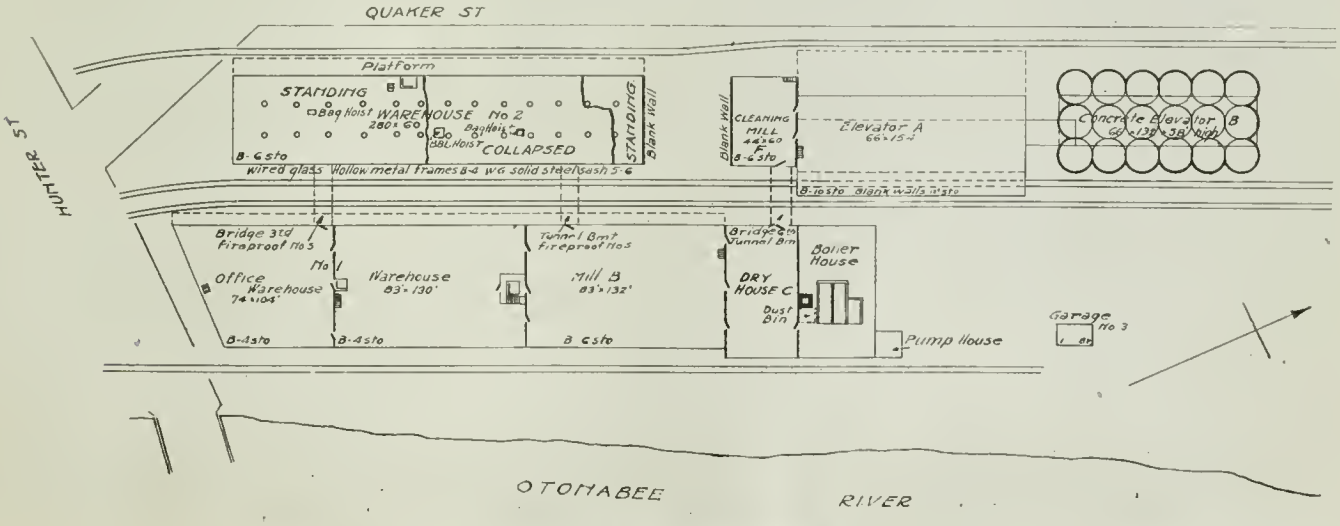


Fig. 2—General Block Plan of Plant.

Mr. Mylrea's conclusions are as follows:—

Mr. Mylrea's Conclusions.—"The first lesson to be drawn from this conflagration is that absolutely 'fireproof' construction is a chimera, for if heat is sufficiently intense and long-enduring, no material can withstand it. This fact has been demonstrated in fires upon practically all the materials of 'fireproof' construction, and now the latest type of building succumbs to it.

"The fact that concrete stood so well in the Edison fire has been hailed far and wide, and the severity of that fire was so great that it has become somewhat of a

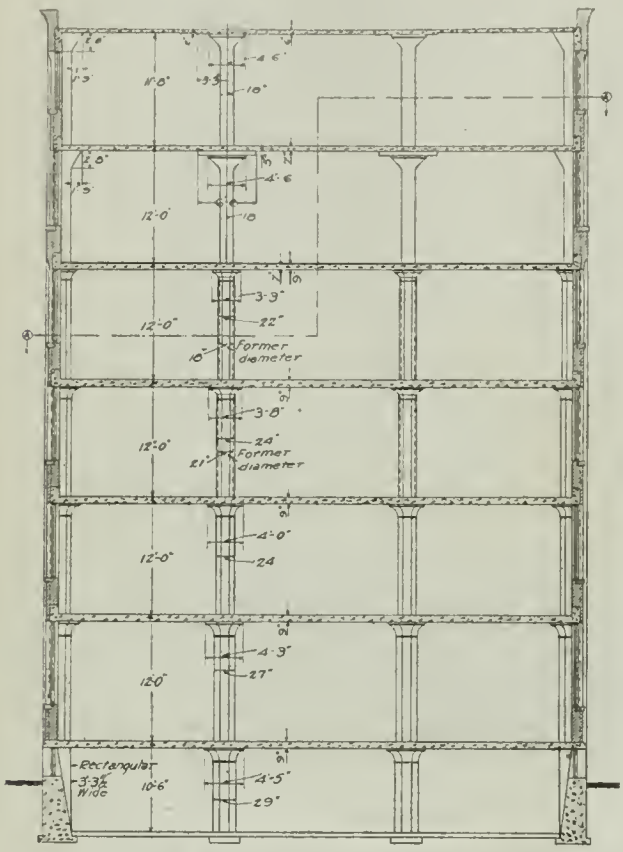


Fig. 3—Typical Cross-Section of Concrete Warehouse.

criterion of fire intensity. It seems almost sacrilige to say that at the Quaker Oats fire, we had a more severe fire than at the Edison plant. Yet, in the press of the time cuts were printed which show that not one of the large concrete buildings of the Edison plant had all the floors in full blaze at the same time. Nor did the fire remain in full intensity for more than an hour or two at any one place. Neither are there more abundant proofs of intense heat.

"But in the reinforced concrete warehouse at the Quaker Oats plant a fire occurred upon all the floors at the same time, of an intensity at least equal to that developed in the Edison fire, and it was seven hours after the fire started before collapse occurred. Even after two months there is considerable heat in the debris, and in some places there is fire still.

"It is not to be considered to the discredit of flat-slab construction that a building of this type failed under such extraordinary circumstances. There was no fusion of the concrete, but the fusion evident at the Edison fire may have been due to the nature of the combustible materials at the points where this occurred.

"A point emphasized again by this fire is that hazardous features should be isolated, preferably in buildings with large window areas. In this case the large blank wall areas of the dry-house tended to hold the pressure. Consequently, not only were the walls wrecked but the fire was flung far into the mill. In several small explosions in Toronto, wired glass has had the effect of holding the pressure, with consequent damage to walls, so the window areas recommended should preferably be glazed with plain glass.

"As far as the matter of fireproofing is concerned, if a fire is of sufficient intensity to heat a nine-inch floor slab through, it is evident that four and one-half inches of fireproofing would avail nothing. Moreover, if it is merely covered with mortar, the reinforcing will not oxidize. In the usual design of flat slab, the steel is not stressed to more than about one-third of its elastic limit under design load, so it could readily stand a temporary reduction in strength of 50%. This would correspond to a rise in temperature of about 1,250° F., at which temperature the cement in the concrete would be completely dehydrated. There is nothing to be gained, therefore, by excessive fireproofing of the rods."

Mr. Pearse's Conclusions.—In an interview concerning Mr. Mylrea's report, Mr. Pearse said:—

"In my opinion, it would be impossible at the present time to erect any building that could resist a fire of the magnitude and duration to which this building was subjected.

"The building apparently was constructed in what is known as the 4-way reinforced concrete type of construction. It will be noted that on the first four floors there were no drop panels at the columns, and also that there was more steel put in the diagonal than there was in the straight or direct strip. This is not in accordance with

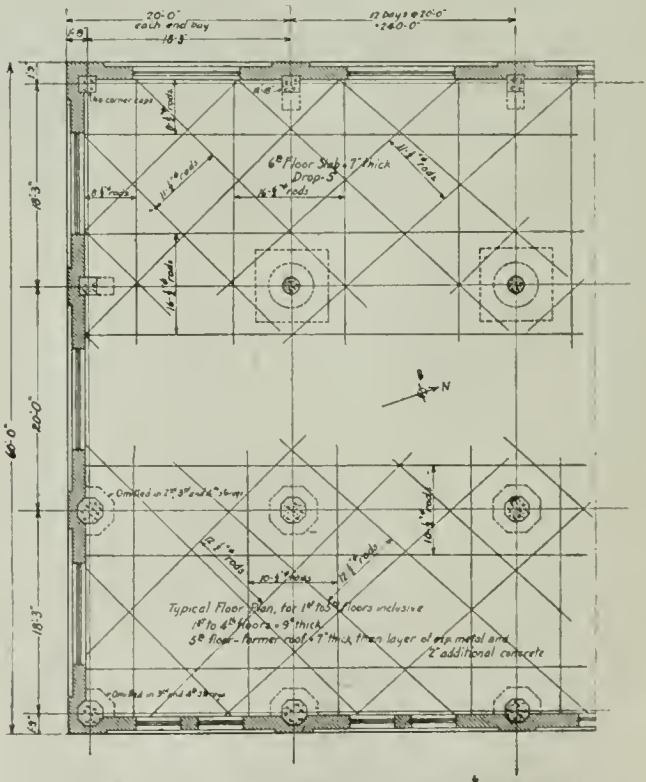

6" Floor Slab, 7" thick
Drop 3'
Typical Floor Plan, for 1st to 3rd Floors inclusive
1st to 4th Floors - 9" thick
5th floor - former roof, 4" thick, then layer of rib metal and 2" additional concrete

Fig. 4—Horizontal Section Through Warehouse.
(Section through A-A of Fig. 3)

the more recent by-laws which usually put more steel in the direct and less in the diagonal strip. Judging from the report, however, the building apparently had stood up under quite severe loading, and due to the fact that the different by-laws covering this type of construction

vary as much as 100 per cent., it seems out of order at the present time to pass any criticism on the way this building was designed."

Fig. 1 is a general view of the plant, all of which was of brick or mill construction, with the exception of the one warehouse which was flat-slab type, reinforced concrete construction, and the circular concrete grain bins,

Fig. 5—The Warehouse After the Fire.

which were of reinforced concrete construction. The grain bins are at the extreme right of the plant, the concrete warehouse at the extreme left, in the rear of Fig. 1, running from the left end of the plant almost to the wooden elevator building on which there was a large "Quaker Oats" sign, and paralleling the mill construction building which burned first and which set fire to the contents of the concrete structure.

The eighteen storage bins were practically uninjured by fire, and represent the only portion of the plant which is not an absolute wreck. Fig. 2 is a general block plan of the plant. The portion of the concrete warehouse which collapsed is indicated, but the remainder of the warehouse is gradually breaking up and is so badly injured that it will be torn down, says Mr. Mylrea.

Fig. 3 gives a typical cross-section of the reinforced concrete warehouse showing the general constructional features. Fig. 4 is a horizontal section showing the kind and amount of reinforcing on the various floors.

The concrete warehouse was approximately 60 ft. wide, 280 ft. long and basement and six stories high. The Leonard Construction Co., Limited, were the engineers and contractors for both the upper and lower sections of the building.

The first four stories were build in 1910 and the two upper ones in 1916, and the common practice at these different dates is well represented in the details of construction. The floors were designed for 200 lbs. per square foot, live load.

Following is an abstract of Mr. Mylrea's detailed report:—

Mr. Mylrea's Report.—From the structural details as shown in Fig. 3, it will be noticed that in the first four stories there are no drop panels at the top of the columns, and that the column caps decrease in diameter with the columns. There is also more steel in the diagonal bands of reinforcement than in the direct bands. The circular reinforcement of the column shafts consist of separate steel hoops about 1½ ins. x ¼ in. in section spaced about 8-in. centres. As the theory of flat-slab construction was not understood at the time these stories were built, these are features that contradict the facts brought out later by extensometer tests, but they represent the best construction known at the time.

The upper two floors show the column capital of constant diameter, the drop panel, the correct distribution of the slab steel, and the spiral form of circular column reinforcement. For some reason or other, the drop panels were omitted from around the caps of the wall columns in the two upper stories and a bracket substituted. On the corner columns even these brackets are lacking.

Since a drop panel would not have interfered with with the windows, it is hard to tell just why this was done, for at these places the bending moments are most severe. It might have been that the type of construction adopted required less work on the forms. It might be fair to state, however, that up until quite recently another American firm had this bracket system as one of its standards, in which case they used four brackets around the interior columns, and no flaring heads.

When the two upper stories were erected, it was decided to increase the diameter of the columns on the third and fourth stories to aid them in carrying the additional load. This was accomplished by wrapping them in expanded metal and pouring a rich grout around them. The fifth floor—the former roof—was increased from 7

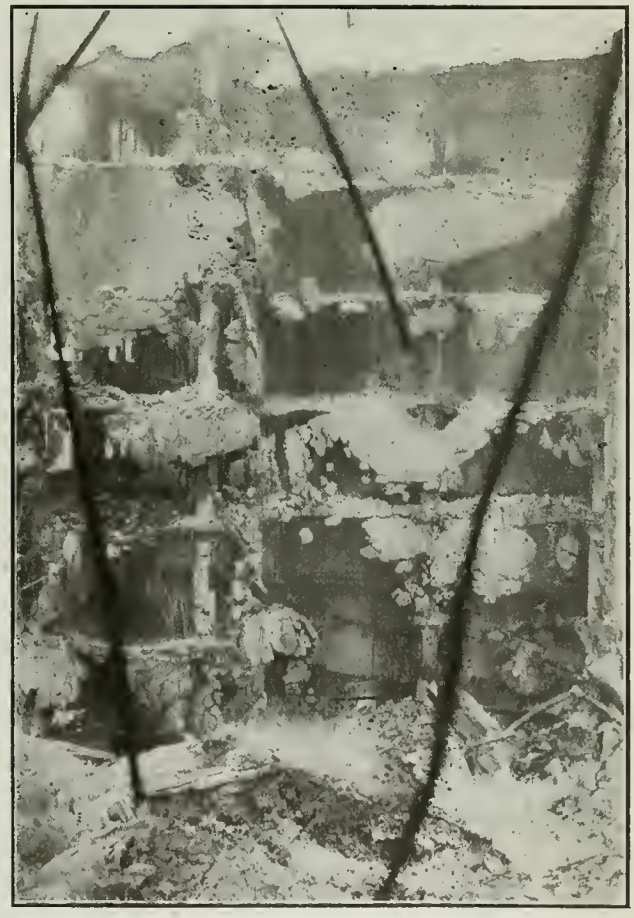


Fig. 6—Looking Directly Toward Standing 1⅓ Bays to the north. View taken from Standing Bays at the south end.

ins. to 9 ins. in thickness by laying expanded metal upon it and pouring another 2 ins. of concrete on it. The aggregate used throughout was a local gravel of good quality.

The north wall of the building was blank. The east wall, facing the lane, between the reinforced concrete

building and warehouse No. 1, had a large number of windows with metal sash and wired glass. The sash and frames in the first four stories were of hollow metal, and in the upper two stories were of solid metal. On the other two sides of the building ordinary wooden frames and sash were used, with the exception of the north bay on the west side, which was the same as on the east side.

All the buildings, with the exception of the concrete warehouse and the concrete grain bins of elevator B, were equipped with automatic sprinklers. All the buildings,

Fig. 7—A "Close-Up" of the Wreck.

with the exception of the circular grain bins, are now in ruins. The lower 15 feet of two of the tanks was somewhat spalled and on the easterly of these two tanks one small hole was burned through the wall. As this was below the level of the floor in the bin it did no damage. Fire smouldering along the conveyer belt passages beneath these grain bins caused an explosion on February 6th which blew the top of one of these bins into the river.

The Fire.—The fire was started about 10:15 a.m., by an explosion in the dry-house. Both the north and east walls of the dry-house were blown out by the intensity of the explosion, and as the plant was in operation and all fire doors open, the mill was filled with fire on all floors at the same time.

There was a fair easterly wind which drove the flames across the bridge into the cleaning building and elevator A; and when the mill and warehouse No. 1 were on fire, subjected the concrete warehouse to a fearful exposure. About 11 a.m. the contents of the reinforced concrete warehouse began to blaze, the fire starting on the third and fourth floors where there were large piles of box shooks. Owing to the lack of pressure, the firemen were forced to leave the building to the mercy of the flames.

Early in the fire the wired glass in the east face of the building was hanging in sheets down the wall, and the wooden frame and sash from the south wall were completely incinerated. It was in the west and middle windows of the second and third floors, that cast-iron sash weights were found partly fused.

The fire raged in the concrete warehouse without one drop of water being poured on it till 6 p.m., when 6⅔ bays north of the centre of the building fell.

In falling, the north wall of the dry-house buried the boiler room, and the east wall carried with it a 6-inch sprinkler riser, at the same time burying the valve controlling this riser. The fire in the mill opened up the sprinklers fed by two 6-inch connections, with the result that with three 6-inch streams drawing from one 8-inch main, the pressure was reduced to practically nil. Thus the private fire protection was put out of commission at the very start, and during the early stages of the fire the city system was badly crippled.

Damage to Building.—So intense was the fire that not even one charred stick of wood may be found on the plant. Fig. 5 gives a general view of what remains of the concrete warehouse. As shown on Fig. 2, most of the concrete building north of its centre line collapsed and Fig. 6 gives a view taken from the fourth floor of the south section looking towards the standing 1⅓ bays to the north. Portions of the floor slabs hanging by their reinforcing rods are plainly visible. A closer view of this wreckage is given in Fig. 7, and a view from another angle is given in Fig. 8. The brick wall in the foreground of Fig. 8 is not a part of the concrete warehouse.

From the distribution of the debris it may be concluded that in collapsing the building settled straight downward.

Temperatures Developed.—Eloquent testimony as to the temperatures developed in the reinforced concrete building is given by expansion cracks. Owing to the heating of the floors and their consequent expansion, the length of the building considerably increased, and caused peculiar diagonal cracks to appear in the brickwork. One curious effect of expansion due to heat was found in the

Fig. 8—Another View of the Wrecked Structure. Wall in foreground belongs to another building.

elevator pent-house. The upper end of the elevator guides came to within an inch of the ceiling formed by the pent-house floor slab. Due to expansion, these guides pushed two holes through this slab.

In the dry-house the limestone has been calcined to a depth of nearly a foot. This is evidence of long-continued heat. At many points about the plant freight cars were standing and all but the metal parts were en-

tirely consumed, and wheels lost nearly all semblance of their original shape. On the rim of one wheel noted by the writer is a fused mass of metal where this wheel and the rail upon which it was standing were fused together. Outside the walls of the buildings a temperature sufficient to melt cast iron was developed in many places.

The temperature in the interior of the building in places must have been very intense, for melted metal parts of machines may be found here and there in the ruins. In the front windows of the second story and in the front and some of the west windows on the third story of the concrete warehouse were found melted sash weights. In some cases they were but slightly fused, in other cases two or more weights had run together, and in several places on the third floor the weights were reduced to shapeless masses of cast iron.

Fig. 9—Melted Brick Ran Out Upon Floor for Distance of Eighteen Inches.

On the inside of the walls of all the buildings may be found large patches of fused brickwork of which Fig. 9 gives an example. This view was taken on the third story of the reinforced concrete warehouse. The melted brick ran down the face of the wall and out upon the floor like molasses for a distance of about 18 inches, and over the doorway it trickled across the face of the concrete lintel and dripped from there to the floor. Upon breaking off some of this fused brick from the lintel, it was found that the concrete had been badly calcined beneath the running brickwork. From the fact that cast iron melts at about 2,200° F. and that brickwork reaches the stage of incipient fusion at about the same temperature, it must be concluded that at many places during the conflagration, temperatures in the neighborhood of 2,300° F. must have been reached. Fig. 10 shows a group of samples collected as evidence of the heat existing.

Cement Dehydrated.—That the concrete building became such a wreck is something that may cast grave doubts upon the fire-resisting qualities of flat-slab construction. Six and two-thirds bays out of fourteen have fallen in an almost shapeless heap of debris. The cement

Fig. 10—Evidences of Extreme Temperature.

A is a partly fused sash weight. B is a piece of iron from a completely fused sash weight. C is a bit of glass from one of the wired glass windows which was sprinkled on the floor. D is a piece of melted brick broken from a wall. E is a piece of brick from a window sill where brick surface and wired glass were melted into one mass.

in the floors of the parts still standing is dehydrated completely through, and when a block of the floor slab, such as may be seen hanging from the reinforcing rods, is detached, it may be broken easily by dropping it on the ground or rapping it against another such block. The floor slabs practically everywhere sag somewhat, and in many places are at the point of incipient failure. Fig. 11 is a view illustrating this condition.

If we consder the effect of heat upon concrete it may shed some light on the subject. Experiments upon the

Fig. 11—Sagging Floor Slabs are at Point of Incipient Failure.

heat conductivity of concrete are rather few, but from those of Prof. Ira. H. Woolson we learn that when subjected to a temperature of 1,500° F. for two hours, a point 2 inches from the exposed surface of a block of concrete had its temperature raised between 500° F. and 700° F. We learn also that dehydration of the cement crystals begins about 500° F. and is complete at about 900° F. Thus we may reason that dehydration has reached a point of 2 inches below the surface of a piece of concrete after

being subjected to a temperature of 1,500° F. for two hours.

In the reinforced concrete warehouse under consideration, we had a temperature that, according to those who saw it, "was like a blast furnace by 1 o'clock," and which at the time of the collapse, at 6 p.m., had lasted five hours. We have seen that it must have reached 2,300° F. and that owing to the great quantity of fuel, must have been maintained practically constantly. The

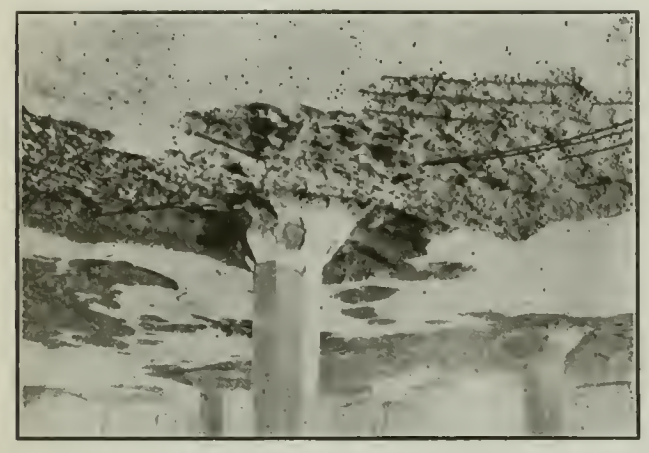


Fig. 12—Probably the Result of Excessive Compressive Stress.

fact that the floor slabs are completely dehydrated is therefore not beyond comprehension, nor does it contradict the evidence of the experiments quoted.

In addition to this, Prof. J. B. Johnson, in his "Materials of Construction," states that the working strength of steel decreases with a rise in temperature, and that this decrease takes place at the rate of approximately 4% for each 100° F. increase. If we take the evidence of the brick shown in Fig. 9, which shows that a temperature of over 2,000° F. penetrated two inches into a material of just about the same conductivity as concrete, and, from this assume that the slab rods reached this temperature, it is evident that their working strength was reduced by about 80%.

For steel with an elastic limit of 35,000 lbs. per square inch, this would mean that the available working strength was less than 7,000 lbs. per square inch. In the columns this would not be of such grave importance as in the floor slabs, but in the slabs the stresses developed were in access of this reduced allowable stress, as will be shown later. It is therefore probable that owing both to the weakening of the concrete in compression and the steel in tension, the floors failed first and carried the columns with them.

Whether any other type of construction would have stood the fire better is, of course, a matter of conjecture, but the shipping shed, which was of beam and slab construction, was wrecked when under no load.

Some Details of the Wreck.—As mentioned above, blocks of the concrete may be readily broken. At a depth of about an inch the aggregate thus exposed shows no noticeable effect, unless it be of some coarsely crystalline structure, such as granite. One such piece of granite as big as a man's fist was easily crushed by the grip of one hand. Closer to the surface the aggregate calcines. The surfaces, being directly in contact with the fire, were everywhere calcined from ¼ in. to ½ in., and on those blocks which fell into the fire in the collapsed portion calcination is practically complete.

At no point is there any evidence of fusion of the aggregate in the concrete. Particular care was exercised in verifying this fact, for in the fire at the Edison Phonograph Works at West Orange, N.J., in 1914, such fusion occurred. At first glance, material hanging from cracks in the ceiling might be taken for fused concrete, but chemical analysis makes it practically certain that this is phosphatic material from "Quaker Oats" which was piled in cases on the floor above. In the exact centre of Fig. 7 is the head of one of the basement columns, and it looks as though fusion had occurred at this point. It was largely for the purpose of determining whether or not this was fused concrete that occasioned my second visit to Peterborough, and I found that conditions had changed considerably since Fig. 7 was photographed. No fusion was evident, but the large calcined masses are rapidly air slaking. This slaking process had already started at the time of my January visit.

All floors had been given a 1-inch wearing surface and practically everywhere throughout the standing portion of the building this 1-inch surface has left the main slab. The ash from the burning box shooks protected some parts of the floor surface during the fiercest part of the heat. Although the wearing surface did not leave the floor slabs so noticeably under the box shooks, it is nevertheless calcined and can be readily separated from the rest of the floor by tapping with a hammer.

There is in this fire much to cause doubts whether gravel aggregate (other than possibly quartz gravel) reduces the fire-resisting properties of concrete. The aggregate is exposed over practically the entire ceiling of the third story and also on other stories in places, and patches of the remaining smooth surface are constantly dropping off. It would seem perhaps more correct, in the case of this building at least, to attribute this appearance to the calcination of the cement and gravel at the surface, which allowed it to fall of its own weight.

In the case of the deeply affected part of the slab around the column head in the foreground of Fig. 12, the

Fig. 13—View in Basement Where Premiums Were Stored.

result is more than likely due to the compressive stress that existed in this locality. Exposed corners on horizontal surfaces suffered everywhere.

The reinforcing rods, even though protected in some cases with a very thin coat of concrete, were not oxidized until exposed. This might have been inferred from the fact that a thin coat of cement mortar will prevent rust, which is somewhat analagous to the black oxide formed on metal when subjected to fire; and wherever a slab failure occurred the broken ends of the rods were drawn down as in any typical tension failure.

The shape of columns seems to have something to do with the damage they sustain. With the exception of two, square ones appear not to be badly affected. But the appearance of all the columns is very deceptive except perhaps those of Fig. 13, which are not so bad, being in a part of the basement where there was less combustible material (premiums such as china bowls, etc.).

The dehydration spoken of before has affected the columns as well as the slabs, and extends to well inside the circular hooping. A month ago this was scarcely apparent. The protective effect of the coat of grout given to the columns on the third and fourth floors was very misleading. The weather in the meantime, however, has caused the appearance of the concrete to change. A month ago a freshly fractured piece of dehydrated concrete could scarcely be distinguished from a good piece, but the weakness is now apparent, the mortar amongst the aggregate having more the appearance of dried blue clay.

It is altogether possible that the hooping on the columns is largely responsible for their not failing. On

Fig. 14—A Few Light Blows with a Hammer will do this to an Apparently Whole Column owing to Dehydration of the Cement by the Extreme Temperature of this Fire.

all columns a few light blows with a hammer will detach large pieces of the concrete outside the hooping, as may be seen in Fig. 14.

Naturally, in heaps of combustible material burning on the outside, gases were formed within the pile and slight explosions thus occurred. There could not have been any explosion of magnitude. The building apparently settled straight downward. A number of columns apparently dropped directly down. As much of the brickwork appears to have fallen inward as fell out.

As to some of the details of construction, the solid metal fire doors stood the heat much better than the wood tin-clad doors when subjected to about the same heat condition. The door shown in Fig. 15 is a total wreck. The other half of this door cannot be found anywhere. The trap doors in the stairway are complete ruins. From this we may reach the conclusion that trap doors can never take the place of a proper stair enclosure.

Early in the fire the wired glass was completely gone, and may be found hanging in sheets down the outside of the walls or running down the brick inside. It must have kept the fire out of the concrete warehouse a little while, for the first fire to gain admittance did so through an open window near the north end of the building; but as

Fig. 15—Tin-Clad Wooden Fire Doors Were Practically Useless.

to resisting severe exposures its value is not great. It is possible that iron shutters, if they had been in working order, would have afforded much better protection; for even if they were not of the automatic closing type, the employees had time enough to close them by hand, as they did the openings in the wired glass windows. The metal window sash and frames withstood the heat very well. The wooden frames were, of course, quickly consumed and the plain glass was worthless.

Loading of the Building.—In the sixth floor the sacked Vim feed was piled 13 sacks high, each sack weighing 70 lbs. over the whole area north of the elevator shaft. Therefore, there was a load of over 175 lbs. to the square foot. The fifth floor loading, Quaker Oats in cases, was comparatively light; and on the third and fourth floors, occupied by the package department, there were no great loads except in a few bays in which were rolls of paper. The second floor was probably the most heavily loaded, for here sacks of oat hulls weighing 98 lbs. each were piled 13 high, and sacks of rolled oats weighing 90 lbs. each were piled 11 high. This loading occupied most of the floor with the exception of a trucking space down the centre. The first floor, occupied by the shipping department, had practically the same loading as the second floor. In the basement were some cases of dishes, some bales of scrap paper, and a large quantity of sacked oat hulls. While this material added no weight to the floors, the ground oat hulls in burning must have helped to weaken the first floor. That the excessive sagging is confined entirely to the wall panels is therefore not at all surprising, nor is it any wonder that in areas of excessive compressive stress the concrete has fallen as shown in Fig. 12. The interior panels all sag somewhat, but the deflection in them is not comparable to that in the wall panels.

TRAFFIC CENSUS: ITS APPLICATION TO THE DESIGN OF ROADWAYS, SELECTION OF PAVEMENTS, AND TRAFFIC REGULATION.*

By D. B. Goodsell, A.M.Amer.Soc.C.E.
Assistant Engineer, Dept. Public Works, New York City.

A RECENT article in "Engineering Record," of New York, deprecated taking a state-wide census on the roads in a nearby state, because such an enumeration would not necessarily indicate the roads to be improved, as travel might, for various undetected reasons, be deflected from the most economical route.

This statement serves to draw attention to the fact that the census is but one of several things to be considered, in designing a road, including determining the kind of surfacing and the width, and that an inventory of all the factors affecting it must be taken, before a final conclusion is reached. The writer does not believe that highway engineers are to-day determining roadways, or the location where main roadways of travel should be improved, solely by scanning a traffic census; there are too many other controlling conditions, and the census is too little known and used, as yet, to be of much service. Nevertheless, it has a place in the design of country roads, and has loomed up recently with a large and important aspect in great cities, as will, I believe, be shown later.

In fixing the width of any roadway surface, the number of lines of traffic to be accommodated should be given consideration. The statement has been made that, where a vehicle has to turn off a hard surface of a road on to an earth shoulder oftener than five times in a mile, it is cheaper to construct the additional width of road surface which may be required, and is far safer.

Now, the necessary amount of clearance which a vehicle must have to pass safely, depends on the speed. The average width of vehicles in New York City has been found to be 6 ft. 9 in., large trucks occupying as much as 8 ft. or 9 ft. At slow speed, say, 10 miles an hour, with the average width, the width of a single line of auto traffic, including clearance, would be about 8 ft., and at fast speeds, 9 ft. or more. On Fifth Avenue in New York City, its busiest avenue, there are six lines of auto traffic, occupying 55 ft., the speed being between 5 and 8 miles per hour. It is obvious that, if the roadway had been made, say, 3 ft. narrower, another line of travel—or possibly two—would have to be sacrificed. The width of the Fifth Avenue roadway was originally 40 ft., accommodating four lines, with too much clearance. It was widened 15 ft., and now takes six lines, with a safe clearance. It is obvious that great congestion would have occurred, and much inconvenience to the public, had the street continued with only four lines of traffic and its excessive width.

On a suburban or country road accommodating auto traffic, the additional clearance required by an overtaking car should be considered. When moving at, say, 25 miles an hour, at least 4 ft. of free way should be given the overtaken car, to avoid accident due to unexpected deflection from its course. A width of 20 ft., for this reason, is better than 18 ft., for two lines of travel, and 30 ft. is ample for three lines.

In the Borough of Manhattan, a realization of the necessity for widening the narrow crosstown roadways of the mercantile district, and some of the north and south avenues as well, took shape in 1911, and has resulted since then in the widening of fourteen streets and avenues 35,012 ft. in length, and apparently the work has just been begun. On all of these streets, a ten-hour census of the vehicular and pedestrian traffic was taken, and resulted in bringing to light places of unexpected congestion, and afforded clues as to how the traffic can be diverted.

It was found that, where the maximum number of vehicles per foot of width per minute exceeded 0.5, there was such serious congestion, that a remedy needed to be applied. Likewise, where the maximum number of pedestrians per foot of width per minute exceeded 5.0, that they flow over the sidewalks into the roadway. Where both these conditions obtained, the street would need to be widened.

So far, this difficulty has been obviated by clearing the sidewalks of stoops, railings, court yards, areas and other projections, thus affording additional space for pedestrians, and then widening the roadway to accommodate the suitable number of lines of travel, provided such widening did not produce an unduly congested condition for the pedestrian traffic. The traffic census has made the strongest kind of supporting data for promoting legislation for the foregoing work, and shows indisputably the need, or otherwise, of street widening.

The influence of the per cent. of horse-drawn traffic on the kind of pavement, its grade, and alignment should be given weight. In cities with intensive traffic, where more than 75 per cent. is auto, sheet asphalt is, in the opinion of the writer, the pavement par excellence; if the traffic is evenly divided into rubber and iron tires, wood block stands out pre-eminently, while, for the slow-moving horse-drawn traffic, amounting to more than 50 per cent. of the whole, close jointed granite blocks are eminently satisfactory, these limitations to be applied, of course, where traffic conditions are considered as the controlling factors in forming a decision.

The difference in traction between these three kinds of pavement, as indicated by tests shown in a pamphlet on "Tractive Resistances of a Motor Truck," by A. E.

(Continued on page 172.)

*Paper read at the annual meeting of the American Road Builders' Association, Boston, Mass., February 9th, 1917.

Large contracts for lumber, aggregating 16,500,000 feet, exclusive of an open order for all the clear spruce available, has been placed by the Imperial Government with British Columbia mills.

Victoria, Vancouver and Chemainus mills will supply two cargoes of railroad ties ordered by the British Admiralty through a San Francisco house, this order approximating 7,000,000 feet.

Another order has been placed direct by the British Government for 3,500,000 feet of lumber, 2,000,000 feet of which will be clear fir, the remainder being heavy timbers, which will be shipped through to St. John, N.B., and handled from that point by British transports.

In addition, a third order has been placed by the Admiralty for 500,000 box shooks, approximating 6,000,000 feet, this order being divided between the Brunette Saw Mills and British Columbia Manufacturing Company, of New Westminster; J. Hendry Company, Vancouver; Lemon & Gounason, Victoria, and the Cameron Mill Company, also of that city.

The total output of clear spruce for airplane manufacture and shipments are being sent overseas as fast as the mills can supply this class of lumber. The new orders are welcomed by the mills, not from the profit standpoint, as the prices are about as low as it is possible to handle the business, but because the placing of these contracts with the British Columbia mills will assure steady operation for some months to come.

SHEET ASPHALT PAVEMENTS.*

By T. Linsey Crossley, A.M.Can.Soc.C.E.,
of J. T. Donald & Company, Chemists, Montreal.

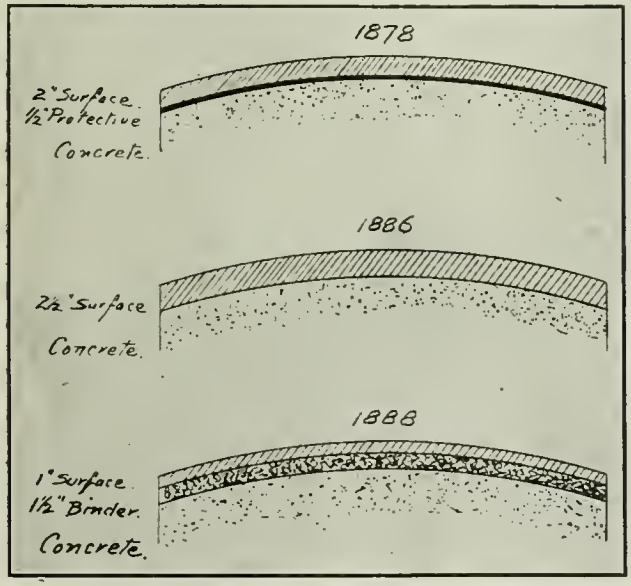
THE four essential parts of a sheet asphalt pavement are: 1, subgrade or foundation; 2, concrete base; 3, binder course; 4, surface or top.

Subgrade.—A proper study of this important element is essential. It is the portion of work most affected by local conditions of soil and topography.

Soils may be roughly divided into three main classes, though of course there are several variations of each: 1, gravelly or sandy; 2, loamy; 3, clay.

The first two classes present the least difficulty to the asphalt engineer. They drain well, and surface waters are not likely to be in contact with the concrete base, thus avoiding frost troubles. Backfilling of excavations can be thoroughly done by watering, with considerable saving of labor and time. The preparation of the grade to good crown and smooth surface is also less expensive. Where the townsite is on a slope of light alluvial soil at no great depth over rock or hardpan, some measures should be taken to prevent shifting of soil under streets running at right angles to direction of slope.

Clay represents the extreme of difficulty in preparing subgrade. Many elaborate means of subdrainage have been used. Different cases call for different treatment, but common sense is of more value than precedent in many cases. The object in view being the rapid elimination of water from the soil immediately under the concrete base.



Development of Sheet Asphalt Since 1878.

According to Richardson the cushion coat of 1878 was put on to protect the friable natural cement from destruction during the hauling of surface material, and the binder course owes its origin to an endeavor to fill the course surface of macadam roads before applying surface mixture.

Preliminary to the preparation of subgrade and of considerable importance is the proper consideration of the condition of sewers, gas, water, and wire mains. These should be closely looked into, repairs made and trenches very carefully backfilled.

In many cases, cable, water and gas mains may be located at sides of roadway so that subsequent repairs will not necessitate breaking up of pavement. It is almost impossible to patch a pavement so that the repair will not present an increasingly noticeable defect. Small towns growing rapidly should be especially careful about the consideration of such pavements, taking plenty of time to find out what future requirements of underground work may arise.

Concrete Base.—The subgrade being satisfactory, or considered so, the concrete base is laid. A 1:2:5 or 1:3:6 cement concrete is used and, except in very narrow streets, should be six inches thick. The surface should be true to crown and free from depressions. The finish should be given by a heavy template.

Failure at Curb.

Bad binder and frost both acting to break up pavement. Sufficient bitumen in binder probably would have prevented this.

It must be borne in mind that a sheet asphalt surface is not a solid but a more or less fluid body and will conform to any variation in the fixed concrete on which it rests. It is impossible to get a smooth asphalt surface over a rough concrete base. It may look right when rolled but a year under traffic will serve to show on the surface the profile of the base.

Binder Course.—This is laid on the concrete base and consists of crushed stone and asphalt, as a rule. It is essential that the concrete be thoroughly set and dry. If this is not the case there is great risk not only to the base itself, but that the moisture given off will honey-comb the binder and surface courses, causing rapid deterioration of the pavement.

There are two forms of binder course, "closed" and "open."

Closed binders consist of crushed stone and coarse sand. The stone should not be "crusher run," as this contains too much fine material, presenting an unnecessary amount of surface. This requires more bitumen and is difficult to lay smoothly.

"Closed" binders should contain little or no material passing 60-mesh sieve, about 15% to 20% passing 10-mesh and about 20% to 25% passing 4-mesh, remainder should pass 1-in. ring for 1¼-in. course, or ¾-in. ring for 1-in. course, to prevent possibility of excess of oversize. This would require for coating about 4% to 4.5% of bitumen. "Open" binder should consist of crushed stone which has been screened free of sizes under ¼ in. It will require about 3% to 3.5% of bitumen.

*Paper presented to the Canadian Society of Civil Engineers at Montreal, January 11th, 1917.

Binder course should look bright and glossy when laid. If it appears dead and dull, it has been overheated or contains fine material in excess. "Open" binder should always look bright. If the trucks bringing binder to the street are dripping noticeably, or if, on spreading the binder, there is a spot completely filled with bitumen, an excess of bitumen is being used. Such spots, if of larger area than one square foot, should be removed. One way of preventing this trouble is to dump the truck ahead of requirements to such a distance that all material must be shovelled over. If any large spots of this nature are left, the excess of bitumen is liable to be drawn into the surface course under the influence of the sun and give rise to soft spots in the pavement.

Surface or Top.—This consists of bitumen, filler and sand. The Trinidad asphalt containing about 30% of finely divided mineral matter requires no additional filler but has to be fluxed with a specially prepared heavy asphaltic oil to the required consistency before being mixed with the sand aggregate.

In addition to sand, dust is required as a filler, to utilize the malthas or liquid asphalts. The science of controlling these aggregates has been developed to such an extent in America that the present use of natural rock asphalts is very limited here, being confined to cities and towns within very short haul of the deposits of the bituminous limestone or rock asphalt. Where the rock asphalt is used the whole of the surface material is hauled, whereas with the liquid asphalts only the ten or twelve per cent. of bitumen is hauled, the material for the aggregate being generally obtained locally.

The filler is cement or limestone dust, preferably cement, and the mixture of sand and cement is graded from 200-mesh to 10-mesh. Sands do not behave in the same way with bitumens. Some will hold more bitumen than others. In connection with the filler, it is desirable, especially if heavy traffic is expected, that a large proportion of the 200-mesh material shall be dust that will remain suspended in water for fifteen seconds, otherwise the fine material is sandy and will not make a road to stand heavy wear. The finest of sands may have about thirty per cent. of voids; in fact it has been shown that the voids in sand do not vary much over quite a wide range of size. The life of an asphalt surface depends on the filling of voids and the complete covering of all particles with bitumen.

Speaking generally, a surface mixture may contain:—

(1) Bitumen, equal to 10.5% to 12.0%.

(2) Filler (200-mesh), 12 to 15 per cent. Three-quarters of this material should be fine enough to remain in suspension in water for fifteen seconds.

(3) Sand, 100-mesh, 13%; 80-mesh, 13%; 50-mesh, 15%; 40-mesh, 15; 30% mesh, 10%; 20-mesh, 10%.

Local conditions, however, may occasion considerable variations. Sand should be sharp and clean. The objection to a dirty sand does not lie in the fact that fine silt is present, but because the particles of such a sand are coated with this silt and therefore are not brought into complete contact with the hot asphalt when the mixture is made.

If local conditions make it necessary to use such sand, it might be cleaned by passing through a revolving screen or by dropping down a vertical chute on to a baffle plate.

Preparation of Specifications.—In connection with a contract for paving with asphalt in any of the various methods, the inspecting engineer and chemist are, or should be, called into co-operation at the earliest stages of the proposed work. They should know local conditions of soil, drainage, and traffic. With these in view, specifications should be drawn up. It has been too frequently the practice to copy specifications of other cities, especially where these are known or reputed to have good pavements.

Especially to be avoided is the inclusion in a specification of some feature introduced with success in one or more cases to counteract some special local condition, or on account of the local availability of some special material. Richardson cites a case wherein an engineer specified cinders for subgrade drainage and insisted on their use. A large quantity was used, subject to a 200-mile haul, when good gravel was available within easy carting distance.

In drawing up specifications for the sand aggregate of a sheet asphalt pavement, the question of sand supply should be studied and the best grading from this supply should be specified. This will forestall the necessity of permitting variants from specifications.

The following is suggested as a preamble to specifications for a sheet asphalt paving:—

"The object of these specifications is:—

"(1) To provide a means of ensuring that a first-class sheet asphalt pavement be laid in the town of Blank,

"(2) To regulate the conditions under which it shall be laid, and

"(3) To state what limits of chemical and physical properties in the materials used, shall be deemed sufficient and expedient to that end.

"Parties tendering to supply and lay pavements under these specifications will be compelled to comply with the conditions set forth, in every detail, without recourse, excepting only as follows:—

"(*a*) That notice shall be made in writing, duly signed, and embodied in their tender, of any variants which the conditions of manufacture or experience of contractors makes desirable.

"(*b*) That said variants be acceptable to the engineer and chemist as not being prejudicial to the laying and maintenance of a first-class sheet asphalt pavement. Variants so permitted shall not be held to diminish the responsibility or guarantees of contractors in any way."

Tests of Asphaltic Materials.—Several pieces of apparatus have been devised for asphalt testing.

The penetrometer records the depth, in tenths of a millimetre, to which a standard needle will sink in the sample, under a stated weight, for a given number of seconds and at a stated temperature.

This seems like a very simple test, but in carrying it out for accurate comparisons, the precautionary sense must be ever alert. The bitumen is carefully heated until liquid, when it is poured into a small tin about 1¾ inches in diameter by 1¼ inches deep. This is kept in the laboratory air for about an hour and is then kept in water of the stated temperature, in most cases 77° F., for another hour. It is then transferred to a crystallizing dish deep enough and wide enough to admit of the tin containing the bitumen being immersed in water of the same temperature as the container in which it has been held. The penetration is then taken by releasing the weighted needle at the surface of the bitumen.

In tests such as penetration and ductility, the low conductivity of asphalts and asphaltic cements must be taken into account. Penetrations should not be made unless the test portion has been standing in water of the required temperature for at least an hour, during which time the temperature must not vary over 1°. One 16-c.p. carbon filament lamp will maintain a temperature of 77° F. in a moderate sized pan with very little attention.

Penetrations at the freezing point require care. The surface of the test sample must be kept at exactly 32° while the test is proceeding, because the needle is released and acts at the surface. In most cases the penetration is only 1½ to 2½ millimeters.

The material to be tested is melted and poured into a tin as described above. This tin is held at the freezing point for one hour, after it has cooled to laboratory temperature, before making the test.

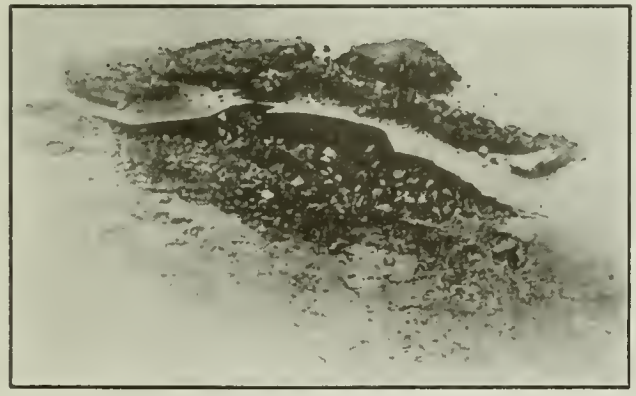
Four penetration tests are usually made on a sample, at 32° F., 77° F., 115° F. and at 77° F. after the material has been heated for five hours at 325° F.

Good refined asphalt and asphaltic cement should not show a hardening of more than ten or fifteen points, and will not lose more than a fraction of 1%. Trinidad and Bermudez asphalts lose a little more than those prepared from Mexican asphalts. A recent sample of Bermudez refined, tested by the writer, lost about 1.5%.

Other tests made are solubility in carbon bisulphide and carbon tetrachloride, and ductility. The last is made by measuring the distance which a briquette, having a cross-section area of one square centimeter at its centre, will stretch horizontally before it breaks. Good "AC's" should run over 100 centimeters when pulled apart at 77° F. at a rate of 10 centimeters per minute. The thread produced as the pulling proceeds varies in thickness a great deal. Some at 100 to 110 cms. show a strong line of about the size of No. 60 thread,—while others at same length show such a fine filament that a glass has to be used when looking for breaks.

Tests not always made, but having more or less value for comparing samples as to uniformity and for determining whether the heating has been carefully done, are: Fixed carbon, ash, flash point, proportion of paraffin scale, and solubility in naphtha (76° or 86°; gravity should be stated).

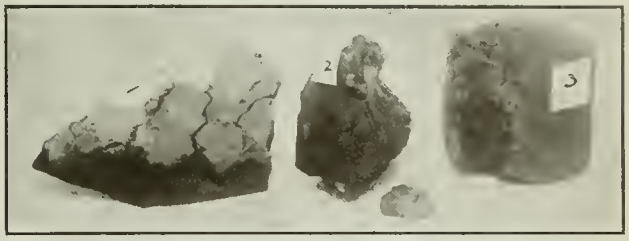
The fixed carbon test has come into undue prominence because too narrow limits have been set for it. The test is subject to fairly wide personal factor, depending on the difficulty of securing exactly similar conditions at different laboratories. It consists, briefly, in strongly heating one gram of the bitumen away from the air for a stated length of time, producing a coke, as in the proximate analysis of coal. The weight of the system is then taken and it is burnt in the air to ash, the difference being the fixed carbon. The thickness, depth and volume of the crucible, the height and intensity of the flame and the time of heating, all affect the results, so that this test must not be considered as an exact one. It yields valuable information sometimes as to the history or origin of the bitumen in question. California asphalts yield a lower fixed carbon for the same class of material than Mexican, for instance.



Break-Up of Binder.

Due to insufficient bitumen. Under traffic the crushed binder tends to pile up, producing waves which eventually break at the crest, admitting water, which very soon puts an end to the pavement, especially when helped by frost and traffic.

The ash test also serves to show something of the past of asphalt. For instance, if a refined asphalt was said to be Trinidad, and showed only 10% ash, we would know it was not straight goods.



Two Bad Samples and One Good One.

Sample No. 1 shows underside of asphalt laid in repair work over cement not set and still wet. The moisture gradually works through to the surface, producing a reticulated appearance, eventually leading to break up of pavement.

Sample No. 2 shows a bad binder condition. There was not enough bitumen in this binder and what there was did not adhere to the stone used. The stone lying loose fell out of the matrix just under the label.

Sample No. 3 shows well made binder and surface; all parts adhering properly.

Low flash point asphalts would be dangerous to workers owing to the necessity of high temperatures in mixing machinery and melting tanks.

Inspection.—When tenders are submitted, it is the custom to submit samples of asphalt, asphaltic cement and flux (only the A.C. sample being submitted, of course, if the A.C. is shipped already fluxed by straight refinery distillation). It is always advisable, besides determining the suitability of a sample and its compliance with specifications, to learn something of its history. Cases have been known where samples of one make were submitted as being of different brands. The engineer or chemical engineer charged with the inspection should make a personal visit to the plants from which the asphalt is to be shipped and note its manner of shipment and the means taken there to control the product.

When the paving is to be done by a contract separate from that for the supply of the materials, it will be necessary, of course, to check quantities received as well as quality. If the contract is to supply a finished pavement, the quality only of the bitumen is to be noted and, of course, the proportions of the aggregate.

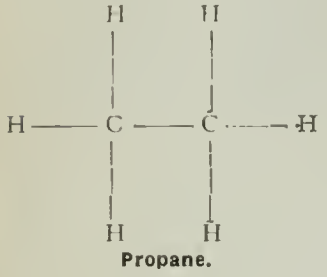
The mixing plant should be closely examined and tested as to the capacity and sensitiveness of its weighing and mixing machinery and method of heating. The means for maintaining a sufficiently high temperature without overheating the material is an important point. With a substance that has such a low conductivity as asphalt, direct heat must be used with great care, especially in starting up with cold material. Some means of circulation should be provided until the material is liquid enough to circulate by convection and even then should be stirred to prevent burning at the bottom. A range of temperature from 350° F. to 425° F. should not be exceeded, either above or below, even in cold weather.

The sand should be heated to the same temperature as the bitumen. While no damage will accrue to the sand by heating to higher temperatures, there is a risk of the asphalt being damaged or burnt by overheated sand. The same consideration affects the heating of the crushed stone used in the binder course mixture.

At a plant of any size an inspector should be employed continuously. It would be his duty to see that weighing apparatus is kept efficient, that asphalt is not

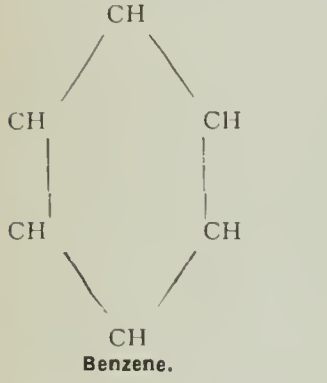
overheated or allowed to get so cooled as to cause mixture to become lumpy at laying point, that sand or crushed stone is clean, of proper grading and heated to the right temperature.

He should have a small, clean room for his own use entirely, a scale weighing up to two or three kilos and sensitive to 1 gram, a set of sieves from 200-mesh to 1-inch ring. It would be well also to have a penetrometer and dishes for the penetration tests, with a supply of water. The penetration tests, however, would usually be done by the city chemist at the main laboratory. In connection with sand test at 200-mesh, or for the testing of



Propane.

Open chain hydrocarbons. "Paraffins"



Benzene.

Closed chain hydrocarbons. Cyclic or Aromatic.

Hydrocarbon Formations.

This diagram illustrates the difference between the petroleum compounds and the asphaltic oils. The latter consist largely of what are termed closed chain or cyclic compounds, whose space arrangement is indicated on a plane surface by one or more hexagonal groups. The petroleum compounds are paraffins whose space arrangement is indicated by a chain-like formula.

dust or cement as filler, there should be provided a graduated cylinder about ¾-inch diameter, holding a little over 50 cubic centimeters graduated to 0.5 cubic centimeters, to test the proportion of suspendable matter, which is the true filler. Seventy-five per cent. of the 200-mesh material should be of such a degree of fineness that on shaking it up with water, it will remain in suspension at least 15 seconds.

The plant inspector should keep records of the loads of surface mixture and binder course, their destinations and heat on leaving. A sample of surface mixture should be taken from the wagon or truck before it leaves the yard and a pat test made to check any tendency to the use of too much or too little bitumen.

Failure of Asphalt Pavements.—Generally speaking, sheet asphalt pavements do not wear out. They "fail" owing to some constructional defect. Failures have occurred from all four parts of the pavement, *viz.*, subgrade, concrete, binder and surface.

Subgrade failures are due to careless backfilling, too great haste in laying pavement where much backfilling is done, or insufficient drainage. Adequate examination of the soil and preparation of subgrade is imperative.

Concrete failures are due to lean mixtures, laying of binder before concrete is thoroughly set and dry, use of dirty sand, or use of old cement.

Binder failures are due to insufficient bitumen, burned bitumen, laying on wet concrete, dirty concrete, binder too cold, excessive oversize in aggregate, lamination in crushed stone, over-rolling of binder when cool, or traffic on binder before top is laid.

Surface failures are due to too little filler with heavy traffic, too much filler with light traffic, too much or too soft bitumen under heavy traffic, too hard bitumen under light traffic, laying top on wet binder, insufficient consideration of climate extremes, or frost working in at car tracks or curbs.

In the writer's observations, failure is due more frequently to binder troubles than to other causes. Attention is focused on the laying and appearance of "top," to the neglect of the binder. With a smooth concrete base and a medium close binder well laid, it should be quite safe to cut down the "top" thickness to three-quarters of an inch.

TRAFFIC CENSUS.

(Continued from page 168.)

Kennelly and O. R. Schurig, may be represented by the following factors, which are averages of tractive resistances at a speed of 19 miles per hour:—

Pavement.	Tractive resistances in. lbs. per ton.
Asphalt	19
Wood and brick	23
Granite	26
Macadam	22.5
Tar macadam	24.5
Gravel and cinder	26.5

The tractive resistances should, in the opinion of the writer, be given much greater weight in the selection of pavements in cities, than is usually accorded them, for the following reason: It will hardly be questioned that auto trucks, in the cities at least, will soon be in almost universal use, and when this is a fact, the consumption of fuel will undoubtedly be carefully examined into, and smooth, light traction surfaces demanded for economy of operation. To-day, with the numerous pleasure autos in use, scant attention is paid to ease of traction, grade or consumption of gasoline, and a scenic highway is at times preferred to the shorter utilitarian route, for which there is going to be an urgent demand by the auto trucks, especially in rural districts.

A few figures as to the growth of the auto truck in New York State are presented. A report of the Secretary of State states that it is estimated that auto trucks travelled over state and country highways in 1915, for 40 weeks in the year, 14,700,000 miles, and that these trucks operated 60,200,000 ton-miles. The number of auto trucks in New York State in the last three years is as follows:—

1914 .... 17,141 1915 .... 20,880 1916 34,653

There were in New York City in 1916 about 21,000 auto trucks, double the number of 1914. In addition, there are more than 100 routes in the State over which heavy motor buses are operating, nearly all of which are less than three years old.

The surfaces which should be placed on trunk highways and rural roads for different kinds and amount of traffic in the State of Massachusetts, have been outlined by Col. Sohier, the chairman of the Massachusetts Highway Commission, in a paper before the American Road Builders' Association, in 1913, on "The Traffic Census as

a Preliminary to Road Improvement." Since that time the auto truck has increased greatly in number, having more than doubled in the State of New York, as shown.

Tables such as the foregoing will soon need careful revision, because of the weights, and the speeds at which these trucks move. The preparedness movement has served to draw attention to the fact that it is desirable to consult the War Department as to the loads to which roads and bridges are likely to be subjected for military purposes.

The increase in the destructive effect of this traffic points to the need of much harder and more durable surfaces than have been afforded by the penetration method of construction—surfaces constructed with one course run of crusher stone with bitumen; sand asphalt roads; broken stone, sand and bitumen roads; carpeted macadam; and other kinds of light traffic bituminous construction.

Recognition of the destructive effect of auto truck travel has led to a readjustment of the registration fees to a higher scale, recently in New York State. Experience with the situation is necessary, in order to determine the exact number of commercial vehicles which may traverse economically certain types of road.

Use of the Traffic Census in the Regulation of Traffic.—The traffic census finds its application to the regulation of traffic, in large cities where congestion is imminent or actual. The Borough of Manhattan has found it necessary to establish 29 streets as one-way traffic streets. These are located largely in the mercantile and theatre districts. Three of them are theatre streets with a one way rule applying one-half hour before and after the termination of performances.

A determination of the amount of traffic in all the streets of any section of a city should indicate where a diversion of the flow is desirable. So far as the writer has been able to ascertain, but one study of the flow of traffic has been made, that being in the city of Bridgeport, Conn., by Alfred S. Miller, as published in "Engineering News" of New York, of January 21st, 1916. The writer believes that such studies are highly important, where there is intensive traffic on a gridiron system of streets, to the end that alternate traffic routes may be laid out, by widening, paving, re-grading or otherwise improving, so that congestion may be avoided, and the orderly transaction of business facilitated.

A number of the large express companies and other corporations now route their vehicles, and have a regular patrol which keeps them constantly informed of the location. A study of the flow of traffic in a large, busy city may offer some difficulties, but would be helped out by instances such as the foregoing.

In the Borough of Manhattan, the Fifth Avenue Association has influenced traffic on that avenue, by encouraging merchants and others to exclude commercial traffic from this distinctly retail mercantile and residential thoroughfare, so that there is now less than 2 per cent. of horse-drawn vehicles of all kinds. This association makes its own traffic censuses, and studies traffic conditions quite independently of the city, and is in a position to make valuable recommendations as to the policy to be pursued.

It was suggested to the police department that more time be given to the north and south traffic than to the east and west, with the result that about 45 minutes of the hour are devoted to the longitudinal travel, while the cross-town traffic takes up the remaining 15 minutes. It has been proposed to divert the through traffic of Fifth Avenue to a parallel avenue, thus affording some relief to this much-congested thoroughfare.

Regulation of Pedestrian Traffic.—It is daily becoming more apparent that, if the vehicular traffic is to proceed with reasonable speed, say, 8 miles an hour on our busiest streets, it will be necessary to regulate the pedestrian traffic as well. It was found that the average time taken by a woman crossing Fifth Avenue—which has a width of 55 ft.—was 11½ seconds. In the busy hours, six vehicles would pass in that time, rendering the crossing difficult and dangerous. There is nothing to prevent a pedestrian from crossing the street at any time he may elect to do so, and he certainly needs to be told when, if the number of accidents which happen is a criterion.

The subject matter of traffic regulation can only be touched on at this time. State-wide co-operation to the end that uniform regulations may be drafted and legislated into laws, is much needed. Attention is directed to the proposed regulations of the State Bureau of Municipal Information of the Conference of Mayors of New York State, embodying the ideas of those most interested in that State. It does not, however, cover the matter of the regulation of the size, weight or construction of the vehicle itself, which is of great interest to the highway engineer.

As to What the Census Should Include.—The traffic census should include observations as to the direction of the flow of traffic, such as left-hand turns; number of vehicles emerging from, or entering side streets; routes of mail trucks and other vehicles; wandering cabs, etc., as well as a knowledge of the various classes of vehicles, if the congestion features of traffic are to be studied. The points at which the count should be taken are worthy of study, and this study is best made by plotting bands of different colors and widths along the roads or streets where the census has been taken. Work of this kind has an intimate relation to building district restriction plans, and to the city plan generally.

Uniformity in methods of taking and recording censuses, and in the assignment of weights, is much needed, for comparisons in different sections. Some office work can be saved by the use of standardized forms, and the writer would suggest that this matter be given attention by the Committee of Standards of the American Road Builders' Association, and that the co-operation of other engineering societies be sought, in making such forms.

In conclusion, the writer would direct attention to the fact that the traffic census has a wide application to city work, in the selection of pavements, street widening, the removal of encroachments, traffic regulation, fixing values of property, opening of new or extension of old streets, operation of street railroads and buses under franchises, determination of the amount of wear of various kinds of pavement under known weights of travel, regulation of the dimensions, weights, etc., of vehicles, and the determination of a paving policy.

On February 2nd, 1917, the technical staff of Wallace & Tiernan Co., Inc., of New York City, celebrated by a dinner the 500th installation of that company's chlorine control apparatus. Many prominent waterworks men and sanitarians were guests of the evening and very interesting remarks were made dealing with the early days of chlorination and the first installation of W. & T. equipment. A souvenir menu illustrated the growth of the organization. A picture therein showed Mr. Wallace and Mr. Tiernan with the first chlorinator, and another showed a portion of the present staff with the 500th machine, mention being made of district offices in Chicago, Dallas, San Francisco, and London.

A NEW TYPE OF TRICKLING FILTER.*

By Lieut.-Col. G. G. Nasmith, C.M.G., Ph.D.,
Director of Laboratories, Dept. of Public Health, Toronto.

THE object of every method of sewage-disposal is to resolve the complicated putrescible organic materials present into simpler, largely inorganic, compounds which are no longer decomposable and incapable of causing offence; in other words, it is to create a harmless and non-putrescible effluent. Such an effluent is commonly said to be "purified."

Methods such as that of the septic tank fail, because, working in the absence of oxygen, they only partially split organic material, and these products of hydrolytic action have still to undergo further destructive processes in the presence of oxygen before they become stable.

Sewage-disposal in the ordinary sense of the term resolves itself in chemical terms to the formula: Organic Matter + Oxygen = Inorganic Matter + Humus (a stable organic material).

The aim of every method of sewage-disposal has been to take advantage of the oxydizing properties of living micro-organisms. Methods which have failed are those which have not provided the necessary conditions; that is, a sufficiently large mass of aerobic micro-organisms, properly harnessed to work in the presence of an abundant supply of air.

Without going into detail it has been established beyond question that the only methods of sewage treatment which fulfil the above conditions are the Trickling Filter and the more recent Activated Sludge method.

The Trickling Filter requires specially prepared bacteria beds, several feet in depth, made of stone, slag, coke, or other resistant material, as a nidus for the bacterial growth. Sewage, when sprinkled or sprayed over the surfaces of such beds, slowly trickles over the pieces of stone until it finally reaches the bottom. In the course of a few weeks the pieces of stone become coated with a pellicle of slime, which has been shown to consist principally of bacteria and protozoa. It is this living slime which, in the presence of the oxygen of the air, oxidizes organic matter.

From the sewage slowly trickling over the surface of this bacterial slime the organic matter is abstracted and decomposed into simpler products. These simpler products are chiefly nitrites, nitrates, carbon dioxide, sulphates and a brownish-black non-putrescible material, easily sedimented, called humus.

If air is excluded from such beds, the oxidizing action soon ceases, or, if antiseptics are added in sufficient quantity to destroy the bacterial slime, the oxidizing action also ceases.

In the activated sludge method of sewage disposal, a similar bacterial mass is gradually formed by blowing finely divided air through tanks filled with sewage. The sludge which forms by this treatment is allowed to settle, the supernatant fluid allowed to run off, and the tank again filled with sewage, after which the process is repeated. By degrees the sludge which accumulates, acquires the same properties as the slime covering the filter-beds. When fully matured, this activated sludge will oxidize the organic matter in fresh sewage in from two to four hours; when agitated continuously with it in presence of finely divided air, a perfectly clear and stable effluent is obtained.

*Excerpt from the Journal of the Royal Sanitary Institute.

The two methods briefly described above are practically identical in principle. In the trickling filter the sewage trickles over the bacterial mass in an atmosphere of air. In the activated sludge method the bacterial mass and sewage are kept in intimate contact by agitation with streams of fine air-bubbles. The end results are exactly the same. Furthermore, as in the trickling filter, the vast majority of the bacterial present in the sewage, including lactose fermenters, and also, presumably, the pathogenic varieties, are destroyed. A single example will suffice to demonstrate several of these statements.

Department of Health Experimental Sewage Disposal Plant, Toronto.

Average Analyses, June 20th, 21st, and 22nd, 1916.

	Free NH3.	Alb. NH3.	Nitrites and Nitrates.	Bacteria per cc. Agar 37°C.	Red Colonies. MacConkey. 37°C.
Raw sewage.....	16.0	7.58	2.66	1,453,333	563,333
Activated sludge-tank, 4 hours blowing 2 cubic feet of air per gallon of sewage	8.9	1.9	12.3	5,690	700
Lath-filter, treating 4.5 gallons of sewage per acre per day...	10.0	1.7	10.4	9,400	1,266

In 1912, in an endeavor to devise a method for the disposal of the city of Toronto's sewage, and reduce the estimated cost of the filter-beds, I began experiments to try to increase the efficiency of the trickling bed, always keeping the principles involved in mind. It was argued that if the amount of surface or bacterial slime could be increased in a given volume, then a greater quantity of sewage could be passed over it and oxydized in a given time.

Experiments were therefore designed with the object of increasing the surface of the filter per cubic yard, and of allowing freer circulation of air than the ordinary types of filter-beds permitted. Wood was selected as the material lending itself best to the problem, and the first filter, six feet square, was made of laths. The laths of the lowest layer were laid parallel to one another, the spaces between the laths being a little less than the width of the laths themselves. A second layer was laid on top of this and at right angles to it, with the same interspace. A third row was laid parallel to the bottom row, but in such a manner that the laths covered the spaces left between the laths of the lower series. In this way a filter four feet in depth was constructed, in which the sewage, in order to reach the bottom, had to flow over a very large surface of filter. Air could enter from all sides and the top through the regular channels provided; in fact, one can see right through this filter, so uniformly regular are the spaces.

Sedimented city sewage was allowed to trickle over the surface of this lath-filter; in less than a month the filter was mature, and the results obtained thereafter exceeded all expectations. Where the standard type of stone filter, operated side by side with it as a control, treated two million gallons of sewage per acre per day, the lath-filter treated six million gallons and yielded a non-putrescible effluent. This lath-filter has now been in continuous use for three and a half years, and has never failed to give satisfactory results.

From these results we argued that poles might give an even greater surface per unit of volume, because the

poles would only come into contact along very narrow surfaces when built into a filter like the laths. Two such filters were built, each six feet square and six feet in depth; after maturing they yielded practically the same results as the lath-filter. They were, however, very difficult to construct; it was difficult also to obtain an even distribution of the sewage flow, and short circuiting of the flow was also liable to occur. This form was abandoned as not being of practical value. One pole-filter, however, was installed in 1914 at the City of Toronto Industrial Farm to treat the sewage from several hundreds of people. No provision had been made for the fact that sewage in small communities frequently comes in gushes, and consequently, as the bed was overdosed at some periods and had no work to do at others, the results were not satisfactory. These defects have recently been remedied.

A filter built of slabs of wood was discarded, as it was only capable of treating sewage at the rate of three and a half million gallons per acre per day.

Finally, having proved our theory to be correct, and having made some preliminary experiments, it was decided that brushwood, pressed into bundles, would make the ideal filter for filter beds, because it would provide the combination of a very large surface area and presence of air which is so essential.

When the town of North Toronto was annexed to the City of Toronto a few years ago it had a system of sewage disposal, part of which consisted of three trickling stone filters, each thirty feet in diameter. In the early spring of 1914 we had the stone removed from one of these filters. Bundles of brushwood, cut from the woods nearby, were made on the spot by means of a rough box-press, wired together, and placed in the filter until a depth of four feet had been obtained. A space of one foot was left between the brush-bundles and the wall, and a small space in the centre so as to allow air to enter freely from the sides. The old revolving distributing sprinkler was then put into operation, the brush quickly became matured, and in two months it was treating sewage at the rate of six million gallons per acre per day. A very high degree of nitrification has been obtained; the effluent has been uniformly stable; and the installation has proved to be a decided success. This brush-filter has now been in operation for two years, and has worked just as well in winter as in summer. Of course, it is always necessary to cover filters of every description in winter in Canada to prevent freezing. A brush-filter that was operated in the open to prove whether this would occur in the Toronto climate rapidly froze solid.

After three and a half years the lath-filter shows no signs of incipient decay, confirming the common experience that wood which is kept constantly wet does not decay. In both the lath and the brush-filter the wood is covered with slime, so that the wood is always soaked.

The advantages of the brush-filter may be summarized as follows: (1) Brush is cheap, and may be obtained almost anywhere; (2) skilled labor is not required in construction; (3) it does not sludge; the slime will frequently become quite thin after heavy rains when the sewage is diluted, though the efficiency of the filter is unimpaired; (4) the brush may at any time be removed and burned; (5) it is durable: a filter has now been in operation for over two years without showing any signs of decay; (6) the distribution of the sewage over the surface of the filter does not need to be very uniform; the general tendency is to redistribute itself in the filter meshwork; (7) it gives the maximum amount of surface, with a freer circulation of air in a unit volume of space; (8) it has proved to be a success when treating the sedimented sewage of a city on a large scale, and has treated three times as much sewage to the acre as the standard stone filter will treat.

Unfortunately, on account of the war, I have not been able to give in detail the results which have been and are still being obtained since the filters were put into operation.* This brief summary is being given in order that others may avail themselves of our experience. Patents were applied for in the year 1914, in order to protect the City of Toronto until such times as our experiments should be completed. No rights or royalties are claimed, however, in connection with the process. In fact, it is hoped that the cheapness of the system will enable communities

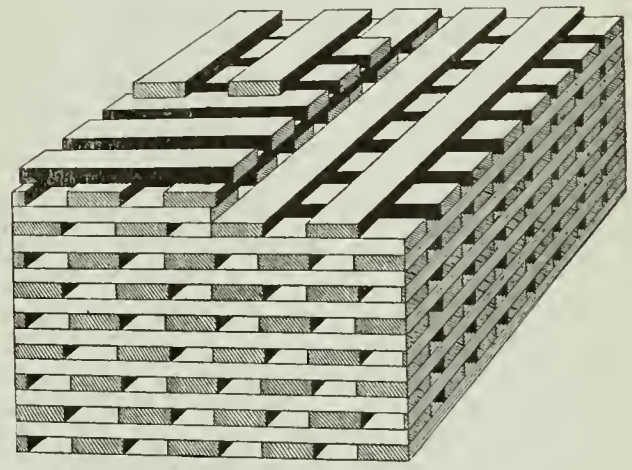


Diagram Showing Construction of Lath Filter.

to install systems of sewage disposal in districts where the high cost of the accepted types of installation have been prohibitive in price. In the prairie provinces of Canada, for example, where stone would in many cases have to be hauled by train for hundreds of miles and costs a great deal, the brush-filter should solve the problem in regard to expense of installation.

In conclusion, I wish to express my great appreciation of the work of my assistants, Mr. J. Scott, chemical engineer, who has carried out the construction of, and has been responsible for the operation of all the experimental filters, as well as the chemical analyses in connection therewith, and Dr. F. Adams, D.P.H., who has supervised this work in my absence. I am also greatly indebted to Mr. R. C. Harris, commissioner of works, and to Mr. Worthington, engineer-in-charge of the sewage-system, through the unfailing co-operation and interest of both of whom it has been possible to carry out the experiments on a large and practical scale.

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*NOTE.—See article, "Brushwood as a Medium for Sewage Filters," p. 117, *The Canadian Engineer*, issue of February 8th, 1917.

The annual report of the Saskatchewan Department of Railways for 1916 recently published contains several interesting statements indicating the growth of railway mileage in the province since its inception, also branch line equipment. The instalments indicate that for the period prior to the commencement of war very great expansion in railway construction took place. The total railway mileage in the province to-day is 6,101.46, divided as follows:—C.P.R., 2,762.75; C.N.R., 2,206.78; G.T.P.R., 1,131.93.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

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BOOK REVIEWS.

The Elements of Refrigeration. By Arthur M. Greene, Jr. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1916. 472 pages, 192 illustrations, 6 x 9 ins., cloth. Price, $4.00 net. (Reviewed by Harry H. Angus, B.A.Sc., MacMullen, Riley and Angus, consulting engineers, Toronto.)

This work covers a field about which comparatively few books have been written in a comprehensive manner. This book is essentially for students and the first part deals very fully with the thermodynamic side of the question and explains all steps necessary to derive the different formulæ used in the practice of refrigeration. The latter part of the book is devoted to practical problems and construction. The general divisions are arranged in good order but the matter in some of the chapters is poorly divided, which is liable to lead to confusion in reading the book.

Starting with a history of refrigeration from ancient times to modern, the work proceeds with a general description of the various types of refrigerating machines in use at present, giving illustrations and a short description of each. The third chapter deals with the thermodynamics of refrigeration and is a very complete treatment of this subject, illustrated by numerous examples.

Following the theoretical treatment, comes a description of the component parts of refrigeration apparatus, giving various types of cylinders, valves, pipes, fittings, etc. Description of apparatus made by prominent manufacturers is described and illustrated and the advantages of the different methods of construction are explained. Another chapter is devoted to heat insulation and gives formulæ by which the loss of heat may be calculated for any type of construction. Methods of calculating heat given out by machines, lights and persons are given.

The remaining five chapters in the book are devoted to problems arising in the design, construction and operation of ice plants, cold storage plants and the applications of refrigeration to the manufacture of different products. Costs of installation are fully dealt with, together with operation tests. At the present time, of course, due to rapidly fluctuating prices, the part dealing with cost of installation is of doubtful value.

The final chapter is devoted to problems illustrating the application of the text, and the problems are typical, so that this part of the work forms a reference for any problems which may arise.

As a whole, however, the work is quite complete and well worth reading by anyone interested in refrigeration.

Underground Transmission and Distribution for Electric Light and Power. By E. B. Meyer. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1916. 312 pages, 156 figures, 6 x 9 ins., cloth. Price, $3.00 net. (Reviewed by D. J. Beatty, Northern Electric Co., Limited, Montreal.)

The steady increase in the demand for power for lighting and industrial work in large cities has made it necessary to place all conducting wires in congested areas, underground. Notwithstanding the gradual evolution in the methods of underground transmission and the big investment of many large operating companies in underground work, very little literature will be found on this subject.

This new book by E. B. Meyer, entitled "Underground Transmission Distribution for Electric Light and Power," will form a valuable addition to existing literature on this subject, and is recommended to engineers and others interested in this class of work.

The subject is treated from a practical point of view and Mr. Meyer's experience as chairman of the National Electric Light Committee on Underground Construction and Electrolysis, 1915-1916, has placed him in a position to obtain valuable data from operating companies in America. The subject is treated in detail, from the construction of underground conduit systems to the final testing, operation and maintenance of underground cable systems. General information is given on the design, methods of construction, comparative costs, protection and operation of different types of systems in use to-day.

An historical chapter gives interesting information on the gradual development of underground distribution work. Working specifications covering the construction of underground conduit systems and the manufacture and installation of underground cables are also of special interest.

One feature of the book which will appeal to a great number of readers is the fact that it is entirely free from cumbersome theory and, therefore, makes interesting reading.

Winter Track Work. By E. R. Lewis, assistant to general manager of the D. S. S. & A. Railway. Published by Railway Educational Press, Inc., 14 E. Jackson Boulevard, Chicago, Ill. 175 pages, illustrated, 5¼ x 8 ins., cloth. Price, $1.60.

Mr. Lewis has given us a notable addition to track literature in his new book, "Winter Track Work." He has had a great deal of experience in handling track work and in keeping traffic open in countries where snow and

cold conditions are severe. Besides this, he brings to his work the knack of writing in an interesting manner on what would ordinarily be a prosaic subject.

There is much of value in this book for the trackman; but not only for the trackman but for the operating man, the traffic man and everyone who is concerned with keeping tracks clear and traffic open in the winter.

The book has ten chapters, embracing the following subjects: (1) Climate and Track, with discussion of the differences in hot, mild, cold, wet climates, etc., etc. (2) Frost; with its effect on track and what must be done to counteract it. (3) Snow; complete discussion of the snow-handling campaign. (4) Shims and Shimming; Good Practice and Bad Practice. (5) Winter Track Force; Tools and Supplies; with especial discussion on the necessity for ample provision. (6) Snow Fences and Snow Sheds. (7) Snow Handling Equipment; with illustrations of many standard and some special appliances. (8) Spring Floods. (9) Storing Ice. (10) Organization.

Books such as this by Mr. Lewis cannot fail to help materially in raising the standard of track work on American railways.

A Manual of Field Astronomy. By Andrew H. Holt, Instructor in Civil Engineering, College of Applied Science of the State University of Iowa. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1917. 125 pages, 8 tables, 25 figures, flexible leather, 4¼ x 6¾ ins. Price, $1.25 net. (Reviewed by Prof. Louis B. Stewart, University of Toronto.)

No apology is necessary for producing a work on field astronomy which is designed to meet the requirements of the engineer or surveyor in his ordinary practice, and which therefore omits methods and refinements which are of interest only to the geodetic astronomer, who will find several standard works containing all the information he requires. Almost the exclusive use which the engineer makes of the subject is in determining the direction of the meridian, but for that purpose a more or less accurate knowledge of time, latitude and longitude, are necessary. Consequently, in the little book before us considerable space is devoted to the subject of azimuth—five methods for determining that quantity being given—and a comparatively small space to each of the other subjects. The Canadian engineer, practising in a country where large tracts of land are yet unexplored, may feel that even in an elementary work on field astronomy more space should be devoted to methods for finding geographical positions, and that it might therefore with advantage include the methods of determining time by an observed altitude, latitude by circum-meridian altitudes, and longitude by lunar observations. Notwithstanding the small compass of the book, however, Professor Holt has devoted ample space to fundamental principles. The subject of time, which presents so many difficulties to the beginner, is very fully treated; also the astronomical triangle, with the various problems related thereto. A chapter is devoted to spherical trigonometry in which is derived the formulæ required in the solution of the astronomical triangle. At the end of the book several useful tables are given, among which may be especially mentioned those for facilitating observations of the pole star for azimuth. A series of examples worked out in full serve to show the application of the methods described in the text and to give forms for computation. This little book may confidently be recommended to the busy engineer who has little time to devote to this subject.

Azimuth. By George L. Hosmer, Associated Professor of Topographical Engineering, Massachusetts Institute of Technology. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. Second edition, revised, 1916. 73 pages, 19 tables, 4½ x 7¼ ins., leather. Price, $1 net. (Reviewed by J. L. Rannie, D.T.S., International Boundary Surveys, Ottawa.)

The subject of azimuth has here been presented in such a manner "that a person who is unfamiliar with astronomy will be able to apply these methods and obtain satisfactory results without taking the time to completely master the theory underlying the method used."

One prefers to believe that those in the engineering and surveying professions are not quite so desirous of avoiding a simple azimuth observation as the author indicates, especially in this country, where a great many engineers have had surveying experience in our western provinces. Nevertheless, methods and formulæ which we use only occasionally have a habit of slipping from our memory and the author has presented the subject in a manner admirably suited alike to the man unfamiliar with astronomy and to the one who has forgotten many of the small practical details of observation and computation. The book is especially desirable, on account of its compact form, for the use of the engineer who desires to observe only occasionally for azimuth and then only approximately and who does not wish to carry the more cumbersome Nautical Almanac.

The methods of observing and the computations involved are described for the following cases: (1) Azimuth by an observed altitude of the sun or star; (2) latitude by the sun at noon; (3) azimuth and latitude by observation on Polaris and another star; (4) meridian line by Polaris at culmination; (5) azimuth by Polaris at any time; (6) azimuth by Polaris at elongation; (7) azimuth by equal altitudes of sun or star.

Examples are given showing the manner of making and computing each method of observation.

The essential features of such a book are as follows and show that the author kept these constantly in mind: (1) The data are defined in simple and non-technical language. (2) The object and limitation of the various methods are well defined. (3) The text is liberally supplied with foot-notes which explain many small but essential details. (4) The formulæ are often written without the use of symbols. (5) The symbols used in the formulæ are few and simple. (6) The formulæ used are adapted to the use of as few tables as possible. (7) The tables are suitably curtailed to suit the required accuracy.

Altogether the author has well fulfilled his purpose of presenting a compact volume for use by the engineering profession.

Elementary Mathematics for Engineers. By Ernest H. Sprague, A.M.I.C.E. Published by Scott, Greenwood & Son, Ludgate, London, E.C. 244 pages, 101 diagrams, 5 x 7½ ins., cloth. Price, $1.00 net. (Reviewed by O. Holden, B.A.Sc., Hydro-Electric Power Commission of Ontario.)

This volume is one of "The Broadway Series of Engineering Handbooks" and deals, as the title suggests, only with the elementary part of mathematics. While the field covered is necessarily of wide range the fundamental principles of each subject are clearly set out and illustrative problems are given showing their application. To the practical engineer whose technical training has been meagre and also to the engineer whose work necessitates infrequent reference to the calculus, etc., this book will prove most helpful.

Engineering Applications of Higher Mathematics—Part V., Electrical Engineering. By V. Karapetoff. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. 65 pages, 5¼ x 8 ins., cloth. Price, 75c. net. (Reviewed by H. W. Price, University of Toronto.)

Engineers as a rule avoid mathematical books written by mathematicians because those gentlemen almost invariably interest themselves only in abstract manipulations. They rarely see the engineer's need of this type of machinery, which becomes valuable only when he has expertness in applying it to known facts and in physically translating calculated results.

The author of this little book is an engineer as well as a mathematician, and has the engineer's point of view.

The book contains six chapters, each including some general information, sample solutions, and problems in great variety with hints and guidance where necessary.

The variety of problems considered is much greater than the titles of chapters would suggest. Some are: Resistance of tapered conductors, leakage resistance of cable insulation; air-gap reluctance of induction motors, and of alternators with graded gap; the minimum weight of copper in branched distribution systems for given loads and voltage regulation, the size of conductors for minimum annual total operating cost of transmission lines; properties of long telegraph lines having considerable distributed leakage over insulators; problems relating to economical design of transformer windings, and of cores in which cross-section is less through the coils than in parts outside the coils; losses in laminated cores, etc., etc.

Those wishing assistance toward skill in applying mathematics to engineering problems will find in this book many suggestions and sample applications.

PUBLICATIONS RECEIVED.

Suggested Specifications for Concrete Floors.—A 10-page leaflet published by the Portland Cement Association, 111 West Washington Street, Chicago.

Public Road Mileage and Revenues in the New England States, 1914.—Bulletin No. 388 of the United States Department of Agriculture, Washington, D.C.

Vapor Pressures of Various Compounds at Low Temperatures.—Technical paper 142 of the Bureau of Mines, Department of the Interior, Washington, D.C., by G. A. Burrell and I. W. Robertson.

Investigations of Gravel for Road Surfacing.—By T. R. Agg. Bulletin 45, Engineering Experiment Station, Good Roads Section, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

The Tractive Resistance on Curves of a 28-Ton Electric Car.—By Edward C. Schmidt and Harold H. Dunn. Bulletin No. 92 of the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 25c.

Department of Mines.—Summary report of the Mines Branch, Department of Mines, Canada, for the calendar year ended December 31st, 1915. Price, 25c.

Public Road Mileage and Revenues in the United States, 1914.—Bulletin No. 390 of the United States Department of Agriculture, Washington, D.C., showing for each state total and surfaced mileage of public roads at the close of 1914, revenues for roads and bridges in 1914, state and local road and bridge bonds outstanding January 1st, 1915, and other related data.

Answers to Problems in Alternating-Current Electricity, first and second courses.—By W. H. Timbie and H. H. Higbie. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. 30 pages, 5 x 7¼ ins., paper cover. Price, 50c. net.

Sun Oils-Refining.—Fourth of a series of illustrated pamphlets issued by the Sun Co., 1428 South Penn Square, Philadelphia, Pa., on the progress and rapid growth of the oil industry.

Province of Quebec.—Municipal statistics for the year 1915.

The Carburization and Burning of Powdered Coal as a Fuel.—A paper read before the American Institute of Mining Engineers, Chicago Section, December 22, 1916, by Alonzo G. Kinyon, chief consultant, Board of Engineering Research in Power Generation in Steam Locomotives, of the Powdered Coal Engineering and Equipment Company, 1903 McCormick Building, Chicago.

The "Mechanical World" Pocket Diary and Year Book for 1917.—A collection of useful engineering notes, rules, tables and data published by Norman, Remington & Co., Baltimore, Md. 453 pages, illustrated, 4 x 6 ins., cloth. Price, 35c.

City Budget Facts, 1916.—An analysis of Toronto's budget for 1916, based upon the official estimates, rearranged by the Bureau of Municipal Research, 813-820 Traders' Bank Building, so as to show costs of services rendered and of things purchased.

Directory of Cement, Gypsum and Lime Manufacturers. Eleventh edition, 1917, corrected to January 1st, 1917. Compiled and published by The Cement Era, 538 South Clark Street, Chicago. 244 pages, 3 x 5 ins., leather. Price, $2.00.

Ontario Safety League.—Third annual report of the Ontario Safety League, Royal Bank Building Toronto, being a brief statement of the fire and accident prevention campaign conducted during the year 1916. R. B. Morley, secretary-treasurer.

National Safety Council.—Findings of the committee of fifty safety experts of the National Safety Council, Continental and Commercial Bank Building, Chicago, summed up in the council's leaflets entitled respectively, "Ladders," "Stairs and Stairways" and "Boiler Rooms."

CATALOGUES RECEIVED.

Cochrane Heaters for Steam Power Plants, as used in heating, metering and softening water for boiler feed and other purposes. Catalogue No. 710 issued by the Harrison Safety Boiler Works, Philadelphia, Pa. Contains 106 pages and is well illustrated.

Concrete Machines.—Miniature catalogue, 1917, of 48 pages, issued by the London Concrete Machinery Co., Limited, London, Ont., illustrating in condensed form the entire line they manufacture.

Motor Trucks of America.—Fifth edition of an annual book distributed gratuitously by the B. F. Goodrich Co., Akron, Ohio, illustrating and giving the specifications of over a hundred different makes of motor trucks.

Mesta Automatic Plate Valves.—Bulletin "D" issued by the Mesta Machine Co., Pittsburgh, Pa., describing the Mesta automatic plate valves (Iversen patent), which are being used in both new and re-built air and gas compressors, ammonia compressors, vacuum pumps and blowing engines.

Walschaert Valve Gear.—Bulletin No. 1018, issued by the American Locomotive Co., New York. Sixteen pages, nicely illustrated.

Editorial

UNPUBLISHED ENGINEERING STUDIES.

There must be a great deal of useful information available in municipal engineering departments which, for one reason or another, does not receive the publicity that it deserves.

Engineering departments, for instance, are constantly carrying on experiments, making studies, etc., which many engineers in similar departments would appreciate knowing about.

In many cases such investigations are too voluminous to be given space in the department's annual report which, for obvious reasons, must be limited in size.

The fact that the results of such studies are in many cases lost is not always due to the lack of a suitable medium for their presentation, but to the fact that those who could make them public and useful to the profession at large do not take the trouble to do so.

It is reasonable to assume that at some time or another engineering departments, at least in our larger cities, conduct correspondence with other municipal engineering departments for the purpose of ascertaining, if possible, what their experiences have been in the solving of specific engineering problems. Doubtless much correspondence of this kind goes on as between departments. There is surely a spirit of co-operation between the different engineering departments to insure team work in matters of this kind.

Is this interchange of experiences given as much publicity as it is entitled to? It is true they are used by the department preparing them and are filed away after they have served their immediate purpose, but is this enough?

The profession as a whole is seldom any better informed as a result of the investigations. There is surely some means by which such information can be made accessible to a larger number of engineers. The technical journals are constantly searching for just such matter, and such investigators will always find the engineering papers willing to give the facts adequate publicity.

METROPOLITAN WATER BOARD AND CHLORINATION.

It is interesting to note that in the last report on research work issued by Dr. Houston, of the Metropolitan Water Board of London, and which has recently come to hand, the admission is made that the substitution of chlorination for storage has been made with strikingly beneficial results.

When it is remembered that the local government board has always refused to sanction schemes involving the constant use of chlorine, in spite of the excellent results that have been obtained on this continent, this admission is rather significant.

Now that the city of London has demonstrated its general utility it is more than likely that the adoption of chlorination will become more general in the United Kingdom.

In the first part of the report referred to, which is the twelfth, the results of investigation as to the best relative positions of inlets and outlets in storage reservoirs are discussed and although no definite conclusions are reached, it is evident that Dr. Houston regards this as an important consideration and especially so when the period of storage is not very long. Some of the results show evidence of short circuiting, a factor which has been extensively studied in connection with some of the American supplies.

The most important part, however, of the report is contained in the section devoted to sterilization. Experiments are described which led to the elimination of one of the large storage reservoirs (Staines) and the substitution of chlorination therefor. This method of purification was apparently forced upon the board by the economic conditions caused by the war; the price of coal advanced to an unprecedented extent, and it became imperative, in the national interest, to reduce the consumption to the lowest possible limit. On May 1st, 1916, the 70 to 80 million gallons of water formerly pumped to the Staines reservoir were chlorinated and passed direct to the filtration plants. The storage reservoir usually reduced the excremental organisms by 90 per cent. and it was decided that the chlorination should effect an equal amount of purification if it were to be regarded as satisfactory. It was found that the dosage of 15 lbs. of bleach per million gallons (0.5 parts per million available chlorine) eliminated over 99 per cent. of the excremental organisms and produced a very satisfactory water for final treatment by the filters. In addition, an important collateral advantage was obtained in the shape of increased filter runs. The percentage reduction in the area of filter beds cleaned in 1916, as shown by this report (June to September), as compared with 1915, was as follows:—

	Percentage reduction.
Grand Junction (Hampton)	6
Grand Junction (Kew)	43
East London (Sunbury)	30
Kempton Park	33
West Middlesex	56
Unweighted average	33

This reduction is attributed to the retardation of algal growths by chlorination.

THE CONSULTING ENGINEER.

It is not so very long ago when it was the rule for a manufacturer who was not an engineer to confine his attention to the trade regarding which he was especially concerned and, when necessity arose, to call in an engineer to advise him as to the purchase of this or that piece of equipment. To-day, however, it is, except in the case of large corporations and public bodies, very frequently the custom for this same manufacturer, to a considerable extent at least, to depend upon his own judgment, aided by those who would sell him the apparatus he is looking for.

One cause for this condition of things is that everybody nowadays has, or thinks he has, a smattering of engineering knowledge which can reasonably be used. Then, again, many salesmen are sufficiently tactful to make what little knowledge they may possess appear to be much more important than it really is.

This does not necessarily mean that the buyer of engineering equipment is ignorant or that the salesman is intentionally endeavoring to sell an inferior article. The point is, is that article the best and at the same time the cheapest for the purpose for which it is required? The untrained buyer cannot know and there is just a danger that the seller consciously or unconsciously cannot but be biased in favor of his particular firm's production.

Circumstances alter cases. For example, there is a great difference between going into the market for a machine of standard design which by common experience has proved to be suitable for the work in hand, and inviting tenders for the supply of a hitherto unknown engineering device concerning the success of which there is but little common knowledge available.

Furthermore, distinction should be drawn between advice regarding design, preceding the actual carrying out of the work, and advice associated with inspection during construction.

One reason why the consulting engineer is not called in more frequently than he is appears to be a suspicion that he may be biased in favor of some particular firm, or class of machinery, or that his services may increase the ultimate cost of contract, or perhaps he may be unnecessarily meddlesome and officious. Such a suspicion is, of course, most unfair to the qualified man.

The task of the consulting engineer who has nothing to sell but his services is not by any means an easy one. His work requires knowledge beyond the ordinary, as it is essential that he have practical as well as theoretical knowledge. He must be tactful, businesslike, just to his client and beyond the suspicion of partisanship.

His qualifications are not merely technical, but moral and temperamental. Character plays, or should play, an important part and the most successful consultants, whether in law, or medicine, or engineering, are men of a certain rare type of mind.

A little knowledge may indeed prove to be a dangerous as well as very expensive thing for those who would too readily dispense with the services of a consulting engineer with a thorough theoretical and practical knowledge of the requirements of the case and who by his education, training and experience is qualified for the special work he is called upon to perform.

PERSONAL.

LEON SPOOR LANDERS has been appointed assistant engineer, Canadian Government Railways, Levis, Quebec.

WILLIAM BEDFORD HARPER has been appointed resident engineer of the Laurentian Division, Quebec District, C.P.R., Montreal.

THOMAS J. McALPINE, of Summerland, B.C., has been appointed road superintendent for the South Okanagan riding by the provincial government of British Columbia.

T. C. MacNABB, A.M.Can.Soc.C.E., formerly division engineer, C.P.R., at Moose Jaw, Sask., has been promoted to the position of superintendent at Revelstoke, British Columbia.

J. H. VICKERS, Vancouver, B.C., has been appointed superintendent of works on the Vancouver Joint Sewerage and Drainage Board's portion of the Stanley Park sewer outfall.

W. R. HARRIS, M.Can.Soc.C.E., has moved from Regina to Winnipeg to take charge of the contract awarded to the Canadian Lock-Joint Pipe Co. on the Greater Winnipeg Waterways.

THOMAS LINSEY CROSSLEY, A.M.Can.Soc. C.E., has just opened an office and laboratory at 43 Scott Street, Toronto, for J. T. Donald & Co., of Montreal. He will specialize in municipal chemistry.

J. W. B. BLACKMAN, M.Can.Soc.C.E., city engineer of New Westminster, B.C., has enlisted for overseas service and has been granted indefinite leave of absence by the city council. H. STEWARDSON, A.M. Can.Soc.C.E., assistant city engineer, has been appointed to act in his place.

R. E. CHADWICK, eastern manager of the Foundation Co., Limited, has just returned to Montreal after an extensive western tour, having visited Seattle, Vancouver and the Pacific Coast generally; Winnipeg, Port Arthur, Sault Ste. Marie, and practically all portions of Canada west of Montreal.

Major JAMES A. DeLANCEY, of the engineering and surveying firm of Lighthall & DeLancey, Vancouver, B.C., has been awarded the Military Cross. He had been thrice promoted for meritorious actions since September, 1915, and was mentioned by General Haig in despatches after the Ypres engagement on June 3rd.

O. W. MEISSNER, M.E., has removed from Commissioners Street West to St. Antoine Street, Montreal. He represents a number of firms making railway, steel, and machinery supplies, is a special agent of the West Coast Pipe Company, Limited, Vancouver, patentee of the O.W.M. air track sander system, and president of the Steel Specialties for Canada, Limited.

J. H. CHOWN has been appointed superintendent of the Regina division of the C.P.R., to succeed J. K. SAVAGE, who has been transferred to the eastern division. M. McKAY, formerly superintendent of the Revelstoke division, has been appointed superintendent of the Saskatoon division, and T. C. McNAB, division engineer of the Saskatchewan division, has been appointed superintendent of the Revelstoke division.

OBITUARY.

THOMAS SCANE, C.E., one of the oldest land surveyors and engineers in the province of Ontario, passed away on February 9th at his home in Ridgetown. Deceased, who was in his 83rd year, was born in Howard township, and was township engineer of Howard and Orford townships for many years.

JOHN STOCKS, a member of the Alberta Provincial Utilities Commission, died suddenly at Edmonton on

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

PETERBOROUGH WATERWORKS

DETAILS OF MODERN WATERWORKS PLANT—DESCRIPTION OF PUMPING EQUIPMENT

By R. O. WYNNE-ROBERTS, M.Can.Soc.C.E.

PETERBOROUGH, a city of about 22,000 inhabitants, derives its supply of water from the River Otonabee, about 2½ miles upstream from, and at a slightly higher elevation than, the centre of the city. The water is pumped direct to the consumers, and as the highest part supplied is only 100 feet above the pumps there is no difficulty in maintaining sufficient pressure.

A reinforced concrete dam, about 300 feet long, thrown across the river, impounds the water in the river for the development of power and as storage for the supply to the citizens. The depth of water behind the dam is about 12 feet and affords an available head on the

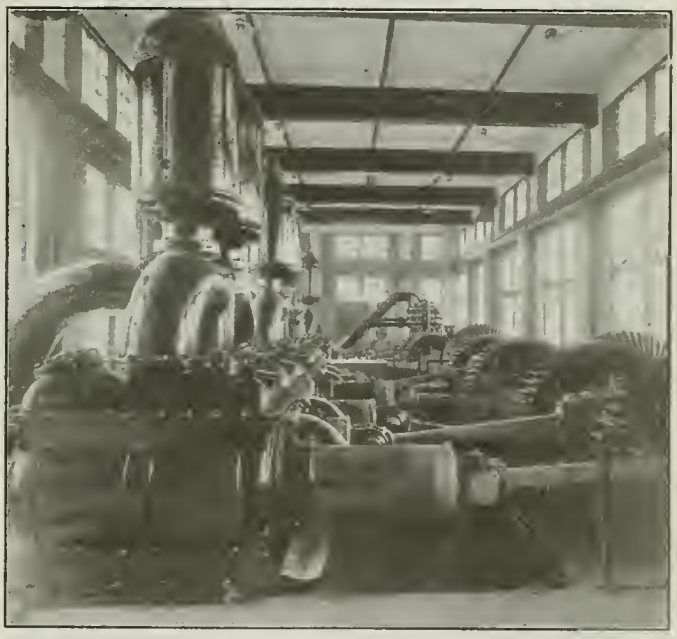
Reinforced Concrete Dam Across Otonabee River.

water turbines of an average of about 10 feet, and the suction lift of the pumps ranges from 3 to 10 feet. Provision is made to draw water from the tailrace, when frazil ice causes trouble above the dam, or when the stream is low and it is desirable to conserve the water for power, the suction lift in this case is about 18 feet.

The pumping station is a substantial building of reinforced concrete framework and brick panels and measures about 125 feet long by 40 feet wide. It houses three sets of water-driven horizontal single-acting triplex pumps, a Worthington centrifugal pump and an auxiliary steam pump. The two oldest pumps were installed in 1893 and are massively built. They have three plungers each 18 inches in diameter, 30-inch stroke, and are operated at 20 r.p.m. when run at full capacity. Each of these are capable of delivering 2¼ million gallons per day. The plunger heads are connected to the crank-shafts carrying massive cog-wheels which are driven by pinions from a horizontal shaft that transmits the power from the water turbines through bevel wheels. The water power is developed by vertical Samson turbines—62-inch wheels. Speed, 66 r.p.m.

The other triplex pump of similar construction was built in 1909 and has a capacity of three million gallons per day. The plungers are 21 inches in diameter, 30-inch stroke, and driven in a like manner to the other by a Samson vertical turbine, having a 68-inch wheel running at about 80 r.p.m. The bevel gear reduces the speed of the pumps to 22 strokes per minute.

There is a 3-stage Worthington vertical centrifugal pump, also driven by a Samson water turbine. The water-



Interior of Pumping Station.

wheel rotates about 80 r.p.m. and by means of an increasing gear the pump is capable of being driven at about 640 r.p.m. The delivery from the pump is rated at about three million gallons daily.

The steam auxiliary pump, installed in 1915, is a De Laval single-stage turbine driven by a 400 h.p. steam turbine running at about 6,000 r.p.m. under 125 lbs. steam pressure. The pump is driven at about 1,385 r.p.m. by the steam turbine by means of the usual reduction gear. This pumping unit is split horizontally for easy access to all parts. The suction is 14 inches diameter and the delivery 12 inches. This pump is arranged to draw water either from above the dam with a suction lift of 3 feet or thereabouts or from the tailrace with a lift of about 18 feet, and is rated at six million gallons per day under a total head of about 228 feet. The condensing plant consists of a Schutte-Koerting multi-jet condenser

and a De Laval centrifugal pump working under 35 feet head at 2,200 r.p.m. and discharging about 700 gallons per minute, and driven by a steam turbine of type T.A.

The pump-house is equipped with an overhead travelling crane carrying a hand-operated 10-ton block tackle.

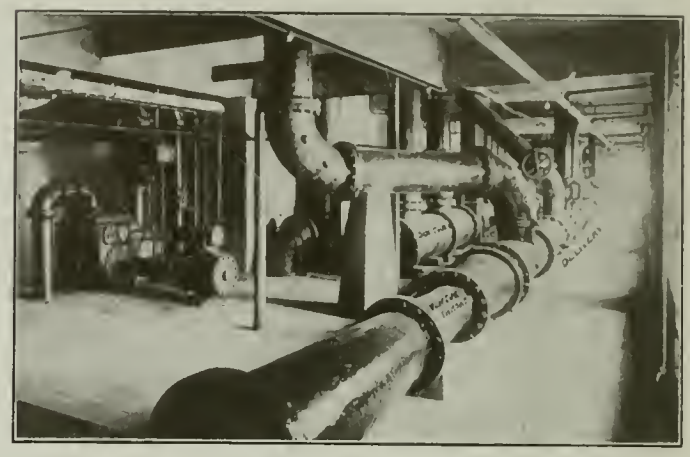
The water-driven triplex pumps and water turbines were made by William Hamilton Co., Peterborough. The Worthington turbine pump was built by John McDougal Caledonian Iron Works Co., Montreal, and the De Laval steam turbine and pumps were supplied by the Turbine Equipment Co., Toronto.

There are two 100-h.p. horizontal return tube boilers each 66 inches in diameter and 16 feet long, fitted with Cyclone shaking grates of 34 square feet in area. A fan to induce draft is belt-driven by a 6-h.p. vertical steam engine, and a 6-h.p. Foos gasoline engine is installed to operate the fan when the boiler furnaces are being started. The boilers are not heated until necessity arises. A Cochrane feed water heater and feed pump are installed. The boilers are placed in a separate adjoining building,

Another View of Pump-house, Showing Worthington Vertical Pump and De Laval Auxiliary Pump.

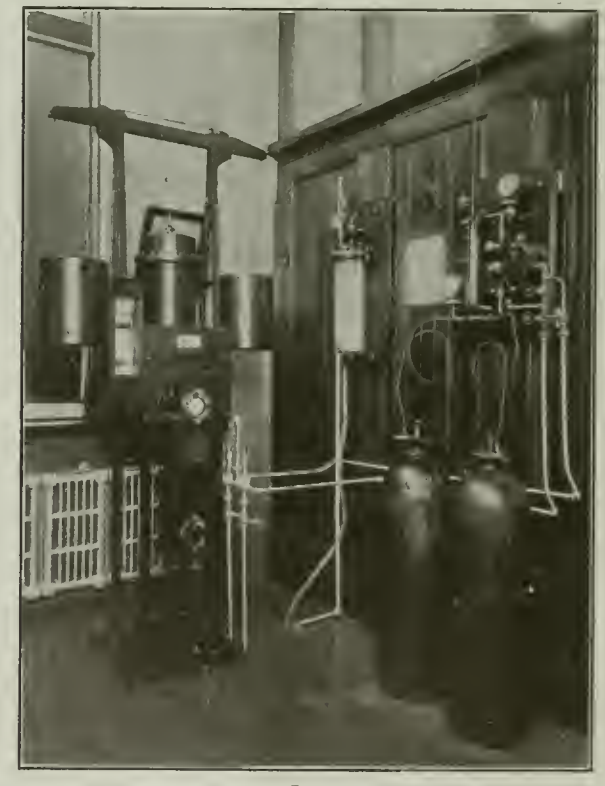
the base of which is reinforced concrete with a brick superstructure, and a laminated wood roof covered with 5-ply Barrett roofing.

The water is pumped from the river through a 30-inch suction header and discharged from the pumps through individual connections controlled by valves into a 24-inch delivery main, in which is inserted a 10-inch Venturi throat to measure the quantity pumped. The Venturi meter recording apparatus is in the office on the main floor, together with a self-recording Bristol pressure gauge and Wallace & Tiernan's chlorinating plant. The meter is type M Builders' Iron Foundry Co. make and needs no description, but it is interesting to note that the Venturi throat referred to not only measures the volume of water pumped but also controls the operation of the chlorinating plant. The differential pressures in the inlet and throat of the Venturi meter are transmitted to the Venturi meter recorder and also to the diaphragm which controls the admission of liquid chlorine according to the varying quantity of water that is supplied. The liquid chlorine is supplied in steel cylinders under considerable pressure and when it is decided what quantity of it must be used to sterilize the water it can be done easily by means of a glass gauge set against a graduated scale. Having noted the volume of water that is being registered by the meter and adjusting the chlorinator scale to suit the required proportion of chlorine to be added, the differential pressures at the Venturi throat automatically regulate the chlorinator for other rates of flow. The liquid chlorine meets with a small quantity of water in a glass vessel and the resulting



Showing Venturi Meter.

mixture is conveyed by a rubber pipe to the suction connection in the pipe gallery. The maximum quantity of liquid chlorine used, is stated to be about 3 lbs. per million gallons but the average in 1916 was 1½ lbs. The chlorine



View Showing Chlorinating Plant.

costs about 25 cents per pound delivered at the pump-house inclusive of all charges.

The pump-house, etc., are steam heated by means of a 30-h.p. horizontal return-tube boiler.

The force mains to the city consist of one 16-inch and one 18-inch cast-iron pipe. These continue well within the city boundaries. The normal pressure at the pumps

is about 70 lbs. and the fire pressure from 100 to 130 lbs. per square inch. There are about 44 miles of mains ranging from 3 inches to 18 inches in diameter, all cast-iron pipe. There are also 4,323 services.

The total quantity pumped in 1916 was about 1,100,000,000 gallons, or an average of about three million gallons per day. The maximum peak rate was about 5½ million gallons per day. The average daily consumption of water in 1916 was about 136 gallons per capita. The cost of the water, inclusive of all charges, averaged about 4.95 cents per 1,000 gallons.

The Peterborough waterworks were first installed by a private company in 1882 and were acquired by the city in 1902.

The water commissioners are Mr. T. F. Matthews, chairman; Messrs. W. H. Moore and Robt. Hicks. Mr. R. L. Dobbin, B.A.Sc., is the waterworks superintendent, to whom credit must be given for the foregoing information, and Mr. Wm. Kennedy, Jr., Montreal, is the consulting engineer.

DESIGN FEATURES FOR CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.*

THE span length for beams and slabs simply supported should be taken as the distance from centre to centre of supports, but need not be taken to exceed the clear span plus the depth of beam or slab. For continuous or restrained beams built monolithically into supports, the span length may be taken as the clear distance between faces of supports. Brackets should not be considered as reducing the clear span in the sense here intended, except that when brackets which make an angle of 45° or more with the axis of a restrained beam are built monolithically with the beam, the span may be measured from the section where the combined depth of beam and bracket is at least one-third more than the depth of the beam. Maximum negative moments are to be considered as existing at the end of the span as here defined.

When the depth of a restrained beam is greater at its ends than at mid-span and the slope of the bottom of the beam at its ends makes an angle of not more than 15° with the direction of the axis of the beam at mid-span, the span length may be measured from face to face of supports.

T-Beams.—In beam and slab construction an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used, extending over the beam and well into the slab.

The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and width of beam is provided, but its effective width shall be determined by the following rules:—

(a) It shall not exceed one-fourth of the span length of the beam;

(b) Its overhanging width on either side of the web shall not exceed 6 times the thickness of the slab.

Beams in which the T-form is used only for the purpose of providing additional compression area of concrete should preferably have a width of flange not more than 3 times the width of the stem and a thickness of flange not less than one-third of the depth of the beam. Both in this form and in the beam and slab form the web stresses and the limitations in placing and spacing the longitudinal reinforcement will probably be controlling factors in design.

Floor-Slabs Supported Along Four Sides.—Floor-slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1½ times its width, the entire load should be carried by transverse reinforcement.

For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of moment to be resisted in each direction. For oblong slabs, the length of which is not greater than 1½ times their width, the moment to be resisted by the transverse reinforcement may be found by using a proportion of the live and dead load equal to that given by the formula, $r = \frac{l}{b} - 0.5$, where l = length and b = breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

In placing the reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the centre of the slab than near the edges. For this purpose two-thirds of the previously calculated moments may be assumed as carried by the centre half of the slab and one-third by the outside quarters.

Loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams, and the distribution will depend on the relative stiffness of the slab and the supporting beams. The distribution which may be expected ordinarily is a variation of the load in the beam in accordance with the ordinates of a parabola, having its vertex at the middle of the span. For any given design, the probable distribution should be ascertained and the moments in the beam calculated accordingly.

Continuous Beams and Slabs.—In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended:—

(a) For floor-slabs the bending moments at centre and at support should be taken at $\frac{wl^2}{12}$ for both dead and live loads, where w represents the load per linear unit and l the span length.

(b) For beams, the bending moment at centre and at support for interior spans should be taken at $\frac{wl^2}{12}$ and for end spans it should be taken at $\frac{wl^2}{10}$ for centre and interior support, for both dead and live loads.

(c) In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moments both at the central support and near the middle of the span should be taken as $\frac{wl^2}{10}$.

(d) At the ends of continuous beams, the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{wl^2}{16}$ may be taken; for small

*From the final report of the Special Committee on Concrete and Reinforced Concrete submitted January 17 at the annual meeting of the American Society of Civil Engineers.

beams running into heavy columns this should be increased, but not to exceed $\frac{wl^2}{12}$.

Flat Slab.—The recommendations in the following paragraphs relate to flat slabs extending over several rows of panels in each direction. Necessarily the treatment is more or less empirical. The coefficients and moments given relate to uniformly distributed loads.

Column Capital.—For computation purposes, the diameter of the column capital will be considered to be measured where its vertical thickness is at least 1½ ins., provided the slope of the capital below this point nowhere makes an angle with the vertical of more than 45°. In case a cap is placed above the column capital, the part of this cap within a cone made by extending the lines of the column capital upward at the slope of 45° to the bottom of the slab or dropped panel may be considered as part of the column capital in determining the diameter for design purposes. Without attempting to limit the size of the column capital for special cases, it is recommended that the diameter of the column capital (or its dimension parallel to the edge of the panel) generally be made not less than one-fifth of the dimension of the panel from centre to centre of adjacent columns. A diameter equal to 0.225 of the panel length has been used quite widely and acceptably.

Dropped Panel.—Generally, it is recommended that the width of the dropped panel be at least 4/10 of the corresponding side of the panel as measured from centre to centre of columns, and that the offset in thickness be not more than 5/10 of the thickness of the slab outside the dropped panel.

Slab Thickness.—The following formulas for minimum thicknesses are recommended as general rules of design when the diameter of the column capital is not less than 1/5 of the dimensions of the panel from centre to centre of adjacent columns, the larger dimension being used in the case of oblong panels. For notations, let

t = total thickness of slab, in inches;
L = panel length, in feet;
w = sum of live load and dead load, in pounds per square foot.

Then, for a slab without dropped panels,

$$\text{minimum } t = 0.024\ L\sqrt{w + 12};$$

for a slab with dropped panels,

$$\text{minimum } t = 0.02\ L\sqrt{w + 1};$$

for a dropped panel whose width is 4/10 of the panel length,

$$\text{minimum } t = 0.03\ L\sqrt{w + 12}.$$

In no case should the slab thickness be made less than 6 ins., nor should the thickness of a floor-slab be made less than 1/32 of the panel length, nor the thickness of a roof-slab less than 1/40 of the panel length.

Bending and Resisting Moments in Slabs.—Analysis shows that, for a uniformly distributed load, and round columns, and square panels, the numerical sum of the positive moment and the negative moment at a vertical section of a slab taken across a panel along a line midway between columns, and another section taken along an edge of the panel parallel to the first section, but skirting the part of the periphery of the column capitals at the two corners of the panels, is given quite closely by the equation

$$M_x = \frac{1}{8}\ wl\left(l - \frac{2}{3}\ c\right)^2.$$

In this formula and in those which follow relating to oblong panels,

w = sum of the live and dead loads per unit of area;
l = side of a square panel measured from centre to centre of columns;
l_1 = one side of the oblong panel measured from centre to centre of columns;
l_2 = other side of oblong panel measured in the same way;
c = diameter of the column capital;
M_x = numerical sum of positive moment and negative moment in one direction;
M_y = numerical sum of positive moment and negative moment in the other direction.

For oblong panels, the equation for the numerical sum of the positive moment and the negative moment at the two sections named becomes

$$M_x = \frac{1}{8}\ wl_2\left(l_1 - \frac{2}{3}\ c\right)^2$$

$$M_y = \frac{1}{8}\ wl_1\left(l_2 - \frac{2}{3}\ c\right)^2$$

where M_x is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension, l_2, and M_y is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension, l_1.

What proportion of the total resistance exists as positive moment and what as negative moment is not readily determined. The amount of the positive moment and that of the negative moment may be expected to vary somewhat with the design of the slab. It seems proper, however, to make the division of total resisting moment in the ratio of 3/8 for the positive moment to 5/8 for the negative moment.

With reference to variations in stress along the sections, it is evident from conditions of flexure that the resisting moment is not distributed uniformly along either the section of positive moment or that of negative moment. As the law of the distribution is not known definitely, it will be necessary to make an empirical apportionment along the sections; and it will be considered sufficiently accurate generally to divide the sections into two parts and to use an average value over each part of the panel section.

Positive Moment.—For a square interior panel, it is recommended that the positive moment for a section in the middle of a panel extending across its width be taken as

$$\frac{1}{25}\ wl\left(l - \frac{2}{3}\ c\right)^2.$$

Of this moment, at least 25 per cent. should be provided for in the inner section; in the two outer sections of the panel at least 55 per cent. of the specified moment should be provided for in slabs not having dropped panels and at least 60 per cent. in slabs having dropped panels, except that in calculations to determine necessary thickness of slab away from the dropped panel at least 70 per cent. of the positive moment should be considered as acting in the two outer sections.

Negative Moment.—For a square interior panel, it is recommended that the negative moment for a section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of the two column capitals (the section altogether forming the projected width of the panel) be taken as

$$\frac{1}{15} wl \left(l - \frac{2}{3} c \right)^2.$$

Of this negative moment, at least 20 per cent. should be provided for in the mid-section and at least 65 per cent. in the two column-head sections of the panel, except that in slabs having dropped panels at least 80 of the specified negative moment should be provided for in the two column-head sections of the panel.

Moments for Oblong Panels.—When the length of a panel does not exceed the breadth by more than 5 per cent. computation may be made on the basis of a square panel with sides equal to the mean of the length and the breadth.

When the long side of an interior oblong panel exceeds the short side by more than one-twentieth and by not more than one-third of the short side, it is recommended that the positive moment be taken as

$$\frac{1}{25} wl_2 \left(l_1 - \frac{2}{3} c \right)^2$$

on a section parallel to the dimension, l_2; and

$$\frac{1}{25} wl_1 \left(l_2 - \frac{2}{3} c \right)^2$$

on a section parallel to the dimension, l_1; and that the negative moment be taken as

$$\frac{1}{15} wl_2 \left(l_1 - \frac{2}{3} c \right)^2$$

on a section at the edge of the panel corresponding to the dimension, l_2, and

$$\frac{1}{15} wl_1 \left(l_2 - \frac{2}{3} c \right)^2$$

at a section in the other direction. The limitations of the apportionment of moment between inner section and outer section and between mid-section and column-head sections may be the same as for square panels.

Wall Panels.—The coefficient of negative moment at the first row of columns away from the wall should be increased 20 per cent. over that required for interior panels, and likewise the coefficient of positive moment at the section half way to the wall should be increased by 20 per cent. If girders are not provided along the wall, or the slab does not project as a cantilever beyond the column line, the reinforcement parallel to the wall for the negative moment in the column-head section and for the positive moment in the outer section should be increased by 20 per cent. If the wall is carried by the slab, this concentrated load should be provided for in the design of the slab. The coefficient of negative moments at the wall to take bending in the direction perpendicular to the wall line may be determined by the conditions of restraint and fixedness as found from the relative stiffness of columns and slab, but in no case should it be taken as less than one-half of that for interior panels.

Reinforcement.—For a column-head section, reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column-head section in question. In the case of four-way reinforcement, the sectional area of the diagonal bars multiplied by the sine of the angle between the diagonal of the panel and the straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction.

Arrangement of Reinforcement.—All bars in rectangular bands or diagonal bands should extend on each side of a section of maximum moment, either positive or negative, to points at least 20 diameters beyond the point of inflection, as defined herein, or be hooked or anchored at the point of inflection. In addition to this provision, bars in diagonal bands used as reinforcement for negative moment should extend on each side of a line drawn through the column centre at right angles to the direction of the band at least a distance equal to 35/100 of the panel length, and bars in diagonal bands used as reinforcement for positive moment should extend on each side of a diagonal through the centre of the panel at least a distance equal to 35/100 of the panel length; and no splice by lapping should be permitted at or near regions of maximum stress, except as just described. Continuity of reinforcing bars is considered to have advantages, and it is recommended that not more than one-third of the reinforcing bars in any direction be made of a length less than the distance centre to centre of columns in that direction. Continuous bars should not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each side of the assumed point of inflection, and should cover a width of at least 1/15 of the panel length. Mere draping of the bars should not be permitted. In four-way reinforcement, the position of the bars in both diagonal and rectangular directions may be considered in determining whether the width of zone of bending is sufficient.

Reinforcement at Construction Joints.—It is recommended that at construction joints extra reinforcing bars equal in section to 20 per cent. of the amount necessary to meet the requirements for moments at the section where the joint is made be added to the reinforcement, these bars to extend not less than 50 diameters beyond the joint on each side.

Provision for Diagonal Tension and Shear.—In calculations for the shearing stress which is to be used as the means of measuring the resistance to diagonal tension stress, it is recommended that the total vertical shear on two column-head sections constituting a width equal to one-half the lateral dimension of the panel, for use in the formula for determining critical shearing stresses, be considered to be one-fourth of the total dead and live loads on a panel for a slab of uniform thickness, and to be three-tenths of the sum of the dead and live loads on a panel for a slab with dropped panels.

The calculation of what is commonly called punching shear may be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the dropped panel, using in each case an amount of vertical shear greater by 25 per cent. than the total vertical shear on the section under consideration.

Bending Moments in Columns.—Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slab, and computations may be made by rational methods, such as the principle of least work, or of slope and deflection. Generally, the larger part of the unequalized negative moment will be transmitted to the columns, and the column should be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

The world's largest artificial harbor is planned for Rotterdam. It will be 28 feet deep and cover 766 acres.

PNEUMATIC CAISSON WORK ON THE PETITCODIAC RIVER BRIDGE PIERS*

DESCRIPTION OF AN UNUSUAL PIECE OF FOUNDATION WORK — VELOCITY OF RIVER, RAPID RISE OF TIDE MADE CONSTRUCTION DIFFICULT — METHODS OF CONSTRUCTION

By E. M. ARCHIBALD, A.M.Can.Soc.C.E.

THE Petitcodiac River is situated at the northern extremity of the Bay of Fundy, and in this neighborhood there occurs the highest tides in the world, the government records showing a rise of 45 ft. at spring tides. At the city of Moncton, located on the Petitcodiac River, some twenty miles from its mouth and at the head of navigation, the rise of tide is only thirty feet, owing to the higher level of the river at that point. Here, at each incoming tide, appears the "bore," a tidal wave due to the onrushing water crowding into the ever-narrowing channels of the river. The bore, although appearing at other points on the Bay of Fundy, is at its highest at Moncton and is most readily seen from that point. This bore varies in height from a few inches to at least four feet—many claim six feet—depending on the stage of tide and velocity of the wind.

Historical.—Directly opposite Moncton is a populous farming country and after long, unsuccessful endeavors to have a highway bridge built by the government, these farmers resolutely and at great sacrifice, raised enough money to start work on the piers for a bridge and managed to keep the project going until after two years' work a bridge was in existence—this was in the year 1869.

Old timers tell of the difficulties in placing the wooden cribs forming the piers; how one after another broke loose from the moorings and was swept away by the swift current, and how eventually the piers were completed, wooden spans constructed on shore and floated out on scows into place—altogether an undertaking of no mean engineering ability. Somewhere about this period, the Provincial Government were brought to a realization of their responsibility and bought the bridge.

Unfortunately, its benefits were not long enjoyed, for in the autumn of 1869 what is known as the Saxby Gale occurred, causing great havoc to shipping and to property, and in the tremendous tide that ensued, the superstructure was washed away and the piers scoured so much that they settled from eight to ten feet in a few cases. However, reconstruction was proceeded with, the piers added to and the superstructure rebuilt. After about twenty years' service the superstructure was again renewed. At the present time the existing superstructure is approximately twenty-five years old, and has been in urgent need of renewal for several years. The life of the old piers, now nearly fifty years old, is past.

About ten years ago natural gas was discovered at Hillsboro and in order to reach the nearest market in Moncton, the mains had to cross the Petitcodiac River. A 10-inch gas main was added to the loading of the old bridge, carried by projecting brackets. Several attempts have been made to lay a gas main in the bed of the river, but without any success. The old bridge continues to be the weak link in the transportation of this very necessary feature to the domestic and commercial life of Moncton.

Location of New Bridge.—The location of the new bridge is 33 ft. up river from the centre line of the old bridge. In considering the location for a complete new bridge, the provincial engineer, Mr. A. R. Wetmore, decided to keep as close as possible to the old bridge for two reasons: (1) Financial—in that the old structure would be of very great service in the erection of the new bridge; (2) soundings showed a ridge of rock closer to the surface of the water at this location than for some considerable distance either up or down river. On the other hand, it was very necessary not to undermine the existing foundations of the old piers. The adoption of the pneumatic system of sinking caissons was decided upon as the least dangerous to the old piers.

River Conditions.—Working conditions in the Petitcodiac River are particularly severe. There is the bore already referred to, the high tides, the high velocity of the current, but perhaps the most discouraging feature is the muddy condition of the water due to the tide sweeping over the extensive mud flats, picking up the mud or silt, carrying it in suspension and depositing it in eddies and at high and low-water intervals. The velocity of the current reaches 10 miles an hour at half tide on what are known as spring tides occurring for a week at each full and new moon periods. At neap tides occurring during the first and last quarters, the tide gradually falls to as low as 20 ft. rise and the current diminishes correspondingly. This rise of tide occurs in a period of three hours, then there is a lull of twenty minutes at high-water before the tide falls perceptibly, after which it recedes very rapidly for three and a half hours, then more slowly. There remains a period of about four hours at slack low water for subaqueous work before the arrival of the next succeeding tide.

Another very annoying condition was the rapid shifting of the channel below the bridge site, caused at times by very high winds and at other times by a freshet or heavy run-off of fresh water carrying tremendous quantities of mud in suspension from the upper reaches of the river and deposited on the flats, causing a bar to build up and thereby prevent the water from running off. A rise in low-tide elevation of as much as 42 inches was observed from this cause.

Ordinary soundings showed from six inches to eight feet of silt on the bottom, below which the material was so firm and compact that an ordinary sounding bar could not penetrate it.

Construction Equipment.—In considering the method to be adopted for construction of the substructures, the weakness of the old bridge and piers and the fear that it would be swept entirely away by the severe ice conditions existing in the winter and early spring, together with the large amount of traffic passing over it, led to the decision to use a cable-way spanning the river, and derricks at each pier for handling all material. It was estimated that the largest block of granite required in any pier would not exceed four tons and that this would probably be the maximum load to be carried on the cableway, but to provide for emergencies, it was designed for a maximum load of six tons. To allow a sufficient factor of safety for the long span of 1,600 ft. between towers, a 2-inch carrying

*Paper read before the Canadian Society of Civil Engineers, February 22nd, 1917.

cable was advisable, but as the contractors had in stock a 1¾-inch cable 1,620 ft. long, it was decided to use it and reduce the working strain in the cable by building higher towers and allowing a heavier sag in the cable. The cable, as installed, measures 1,591 ft. between towers and can be adjusted for a minimum sag of sixty feet. The cable in stock was short by about 200 ft. of the length required to span the river and over the towers to the anchorages. This was overcome by splicing short pieces to each end, the connection being made by drop-forged sockets. The anchorages were made by excavating to a depth of 6 feet in the ground 20 feet wide and 20 feet long, building a crib platform carrying 100 tons of stone for ballast, the main cable being carried to the bottom and around a very large birch log. A turnbuckle at one end provides for taking up about 6 feet of slack in the cable. The tower on the Moncton side is 90 feet high and has a base of 23 feet wide by 30 feet lengthways of the cable. The front legs of the tower are set on a batter of one in five, which falls within the resultant of the forces acting on the tower. The tower on the Albert County side of the river is on a higher elevation and in consequence was only built 85 feet high. The centre line of the cable was located 14 feet up river from the centre line of the new bridge. The stringing of the main cable across the river presented a problem in itself as it was necessary to keep the cable out of the swiftly running current of the river, which, with the maximum sag permissible and with the weight of this main cable, required the strength of the supporting wire to be 14 tons during erection. This was solved by using the two ⅝-inch wire ropes, later used for the hauling cable, as a carrier for supporting the weight of the main cable, this main cable having snatch blocks wired to it every 200 feet, which travelled along on the two supporting wires. The cableway outfit is a Flory design, the engine having two 8½ x 12-inch cylinders, link motion, and two 42-inch drums. The hoisting and hauling ropes are each ⅝-inch diameter wire rope.

For mixing concrete, a battery of two ½-yard Smith mixers was used, located directly under the cableway. Gravel was shovelled into ½-yard cars at the storage pile, cement added to make the required batch and the whole hauled up an incline to the mixer platform.

Two 40-h.p. locomotive boilers were used for the first year's operations, previous to the installation of the pneumatic plant. Two hundred and twenty additional boiler horse-power was added later to take care of the pneumatic work.

The compressor plant was located immediately alongside the boiler plant and consisted of one 1,150 cu. ft. Ingersoll-Rand compressor, 18 x 24¼ x 24 and a second of 1,250 cu. ft. capacity with cylinders of 24 x 24¼ x 30. The air, after being compressed, passed into a 42-in. x 14-ft. receiver, thence by two lines of 4-in. pipe located along the old bridge, to the work.

A derrick car was used in the granite storage yard for unloading the granite from incoming cars and afterwards reloading on small cars running to a point directly under the cableway, whence it could be picked up and carried to the pier under construction.

The floating plant consisted of one "A" frame derrick scow 60 x 25; one 68 x 28 and three 45 x 16, all with flush decks. This floating plant was seldom used on account of difficulty in handling in this turbulent river.

Water obtained from the city water supply was carried through 1,200 ft. of 2-in. pipe to the boilers and mixers and a 1-in. pipe line extension to the different piers under construction.

Construction Work.—The north abutment was excavated about 6 ft. below the surface of the ground, after which piles were driven and the concrete poured directly from the mixers. This abutment was above high tide.

Pier "B" was foundationed on piling 10 ft. above low-water mark, the excavation being sheet piling. The only difficulty encountered here was due to the heavy sediment deposited by each tide, which had to be scoured off before concreting could be continued.

The excavation for the south abutment was carried to rock, which was reached 12 ft. above ordinary low-water mark; the excavation was sheet piled to prevent the banks falling in when the tide filled the excavation. A concrete footing course 6 ft. thick was poured and the granite then started. No difficulties were encountered with this pier.

No. 4 pier was founded on rock at extreme low-water mark, the rock being levelled off at slack-water periods to a level bottom 6 inches below extreme low tide. A grillage 30 inches thick was accurately placed on this levelled-off bottom, forming a footing for the granite pier. No great difficulties were met with in the erection of this pier, except for the precautions to prevent the tide washing away the green concrete hearting. Tarpaulins were used for this purpose, covering the entire work and being roped down solidly to the birch grillage just before the arrival of the bore. Notwithstanding all precautions taken, a small quantity of the concrete hearting would be washed away and a deposit of mud left by the tide, which would have to be scoured off before pouring any more concrete. To give some idea of the force of the current at this pier, it may be mentioned that granite blocks placed on top of the tarpaulin to hold it down, were displaced by the current, and in one instance several granite blocks containing as much as a yard apiece were washed off the pier.

When taking soundings at the location for No. 3 pier, it was found that the bottom was scoured clean to the rock and was only 5 feet below low-water for over half the length of the pier at its centre, but dipped to a depth of 9 feet at both upstream and downstream ends of the pier. It had been the intention to use the pneumatic system in foundationing this pier, but as a result of these soundings it was decided to build an open caisson with the sides fitting the bottom and with a puddle chamber on the outside, so that the water could be pumped out and the rock cleaned before concreting. This caisson was built on shore with a puddle chamber 2½ feet wide surrounding it. Just previous to high tide it was launched, towed to its position and moored through the ebb tide. Towards the end of the ebb tide it was placed accurately in position and ballasted with rails. The puddle, consisting of clay and gravel, was placed in the puddle chamber and completely covered with gravel in bags to prevent scour by the tide. Just when ready to start pumping operations a period of heavy rains came on, bringing down with the fresh water large quantities of silt, which deposited on the bars in the river and caused a rise of 3½ feet in low tide elevation, and this rise of water caused endless trouble, since the puddle chamber had not been designed for so much pressure and when pumped out it would blow repeatedly. Fortunately, the caisson had been bulkheaded into four water-tight sections. Pumps were placed in one section at a time at the early part of low-water period and by pumping each compartment separately the bottom was cleaned of sediment and concreting carried on at low-tide intervals. Several tides were required to fill each compartment on account of the delays caused by cleaning operations at each tide. A tar-

paulin was battened down on top of the green concrete at the completion of each tide's operations to prevent scour.

Concrete was stopped 2 feet below low-tide mark, after which 3 feet of hardwood timber grillage was used to form a footing for the granite pier.

The work already described was performed from the time operations started in July, 1915, to the end of the same year.

Pneumatic Caissons.—The responsibility for the design of the caissons was entirely in the hands of the contractors, except for the outside dimensions. Further, the engineer's requirements that no concrete be deposited through water, in addition to the launching and holding problems, presented a set of conditions none too easy of solution. To fulfil the first requirement, the caisson was divided into three parts with two water-tight bulkheads, so that any one compartment could be pumped out and concrete deposited in the dry space during low-tide periods. This shortened the time of pumping and permitted longer time for concreting and also reduced the buoyancy, as only sufficient weight was necessary to overcome the displacement of the pumped-out chamber and the natural buoyancy of the caisson.

No. 1 caisson, as launched, was built 18 ft. 9 ins. high, with 18 ins. of concrete on the roof of the air chamber, floated 13 ft. 6 ins. deep and weighed 370 tons. At the time of launching, three-quarters of an hour before high tide, there was only 15 ft. of water available at the end of the launchways. The intention was to launch early enough before high water to permit the caisson to be towed to place and the moorings secured before the turn of the tide, then to place enough timber on the top of the caisson so that when sunk in place the top of the caisson would be above low water. Intentions are not always carried out and it proved so in this case, for the launching was not successful. The caisson slid off the ways, sideways, just after starting. However, after jacking up, the above programme was followed. The caisson was launched successfully, towed across the river, moored, and several courses of timber placed. The moorings held through one ebb and one flood tide, but parted at about half ebb the second day. It is only fair to state that this accident was due to an extremely heavy surge of the current. The caisson grounded on a mud flat about six hundred feet below the bridge and partially rolled over, enough to expose one cutting edge at low tide. Here she lay, the sand scouring until she had enough bearing to carry, but resting in a hole in the sand 18 feet deep and sand banked up to the water's edge within 30 feet of the caisson. How, after rolling over several times, she was finally floated and brought back to place, might be interesting, but the writer can assure you it was just a succession of difficulties, not the least of which was the continued rainy weather. Simply, it consisted of righting the caisson and holding until she could be pumped out and nursed into a convenient place for handling.

(To be continued.)

TRANSCONTINENTAL OF AUSTRALIA.

Up to July 29th, 1916, the cost of the east-west transcontinental line of Australia from Kalgoorlie to Port Augusta was $20,683,970, exclusive of rolling stock and stores on hand. Rolling stock had cost $3,352,361. Recent advices say that 917 miles have been laid and that only 41 miles are required to complete the railway.

A NEW ORGANIZATION TO HELP WIN THE WAR.

The engineers and technical men belonging to the various branches of the profession in Ontario have recently organized to lend their technical knowledge in the service of their country.

The new movement is known as the Joint Committee of Technical Organizations, Ontario Branch, and is governed by a strong committee composed of representatives from all the known engineering associations of the province.

Representatives have been selected from such institutions as the Canadian Mining Institute (Toronto branch), Canadian Society of Civil Engineers (Toronto branch), Ontario Association of Land Surveyors, Society of Chemical Industry, Canadian Section (Ontario members), Engineering Alumni Association of the University of Toronto, Engineers' Club, Toronto, Royal Canadian Institute, Canadian Engineers (Military District No. 2), American Society of Mechanical Engineers (Ontario section), American Institute of Electrical Engineers (Toronto section), Institute of Electrical Engineers (Ontario members), Ontario Association of Architects.

As the members of the committee are probably as busy men as are to be found in the community, meetings are held once a week only, but a small executive meet three or four times weekly and report at the weekly meeting to the representatives of the above-mentioned societies.

That there is ample scope for good work from such a galaxy of knowledge as is represented at these meetings is evidenced from the fact that after less than a month's existence matters in hand embody nearly all interests connected with the war, from aiding recruiting in the engineering branches of the service, to giving technical advice when requested to the Munitions Board, munition manufacturers, and others engaged in war work.

The committee is making a canvass of the province to register all engineering ability of every sort and description, and cards have been distributed to the members of all the societies, asking for accurate information as to each man's special experience and qualifications.

This information should prove useful when obtained, as Ontario is called upon to organize her resources, mental as well as physical, to defeat the common enemy.

Through the efforts of this committee similar organizations are being brought together in the other provinces, and already Nova Scotia, Manitoba, Saskatchewan, British Columbia and Alberta have active work started to organize engineers for any work that may be delegated to them.

The objects of the association are clearly defined in their rules, which read as follows:—

"The object of the Joint Committee shall be to devise ways and means by which engineers and other technical men may, as a result of their special training and experience, render assistance in the development and government of our Dominion. The immediate aim shall be to evolve a plan or plans whereby such of these men as for business, family, or other reasons, are unable to go to the front, may be used for war purposes at home in such a manner as their special technical training may make them most valuable."

Any engineers not affiliated with any of the above associations and willing to lend a hand should apply to the secretary's office for a registration card.

The office of the Joint Committee is in Room 710 of the Excelsior Life Building, Toronto Street, Toronto.

CONSTRUCTION METHODS FOR ROGERS PASS TUNNEL.*

By A. C. Dennis, M.Am.Soc.C.E.

THE Rogers Pass Tunnel is a double-track tunnel, slightly more than five miles long, being part of a local improvement, about 10 miles long, of the Canadian Pacific Railway Company's main line through the Selkirk Range, in British Columbia. The map and profile are shown on Fig. 1.

The writer, knowing that the time of construction of this tunnel would weigh heavily with the railway company in considering bids, gave considerable thought to devising some quick method of construction. The usual American method of driving a top heading and taking out the bench with a power shovel was obviously too slow, and the ventilation would be too difficult, for a tunnel of this length. The European method, of a bottom heading and stoping out the rest of the section, would be too expensive, under existing labor costs. Shafts or adits were impracticable. It was finally concluded that a working tunnel or "pioneer heading" entirely outside of the regular tunnel section would be economically justified, under the existing conditions.

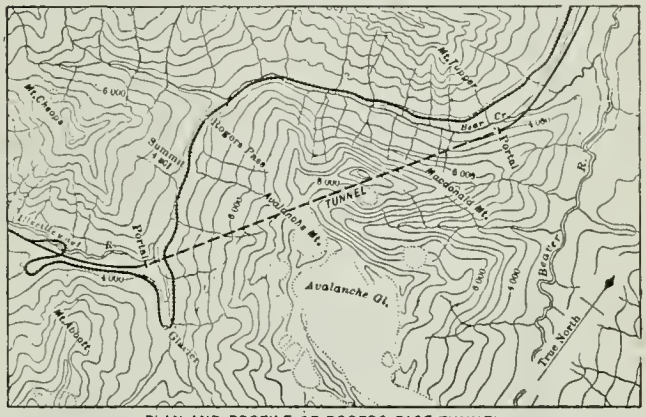
It was possible to keep the heading progress, enlargement drilling, enlargement blasting, and mucking going continuously, without any interference with one another whatever.

Bids were asked for this tunnel work early in 1913, and the contract was let to Foley Brothers, Welch and Stewart, railway contractors, in June, 1913. This firm was not the lowest bidder, but undertook to do the work more quickly than other firms, its estimate being based on the proposed pioneer method, Mr. Stewart, of the contracting firm, and John G. Sullivan, M.Am.Soc.C.E., chief engineer of the Canadian Pacific Railway, being willing to take the risk of this untried method. The first study contemplated a top heading, but, at Mr. Sullivan's suggestion, this was changed to a location midway in the full section, so that the heading could be made smaller and still permit holes to be drilled far enough to break to the full section; otherwise, the work has been done as planned by the writer, and under his superintendence.

Plant.—There was a power plant at each end, with five 150-h.p. boilers, equipped with special grates and induced draft, so that slack coal could be used for fuel. The boilers were run generally much beyond their nominal rating.

Each end had a capacity of about 4,000 cu. ft. of low-pressure air; that is, air at from 100 to 125 lbs. at the compressor, with from 90 to 100 lbs. at the drills, and a capacity of 1,500 cu. ft. of high-pressure air; that is, from 1,000 to 1,100 lbs. pressure at the compressors, and from 800 to 900 lbs. pressure at the charging stations. Ingersoll-Rand compressors were used, two-stage for low and four-stage for high pressure, with inter-coolers. The steam ends were compound condensing. The compressed air passed through an efficient after-cooler, so that little trouble was caused by the freezing of moisture in the compressed air when exhausted by drills, pumps, and blowers. The plant was properly put in and properly looked after, and caused practically no delay.

Wall-plate drifts were started in January and February, 1914, as soon as the approach cut was down to the wall-plate grade, and finished to rock in July. From these drifts a stope was started in March, and segment timbers were placed for about 100 ft. Owing to a change of plan by the railway company, this segment timber had to be removed and rebuilt to a larger section, so that stoping and timbering ahead of this point could not be resumed until June. The timbering from the wall-plate up was completed in October. A locomotive crane was found very useful for taking the timber and other material from the framing yard and delivering it in the wall-plate drifts. After the wall-plate drifts met the main heading, in July, the material from the break-ups or stopes was hauled to the first cross-cut and out of the pioneer heading, so that it would not interfere with the timbering. Previous to that time it was dumped at the portal and reloaded by the steam shovel, together with the material of the approach cut. The material from the break-ups was passed down through a chute into the small tunnel cars. Considerable turning and crushing of the wall-plate occurred, necessitating a great deal of propping of the segments.



PLAN AND PROFILE OF ROGERS PASS TUNNEL

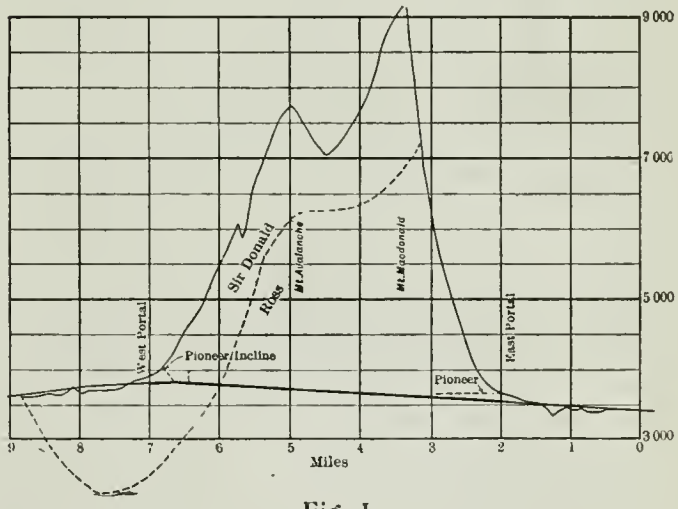


Fig. 1.

In August, the steam shovel, having finished the approach cut, started on the tunnel excavation, being operated by compressed air. During the day shift, the wall-plate was supported on temporary batter posts as the shovel progressed, and the night shift straightened the sides and set the plumb posts and lagging. During the night shift, the locomotive crane delivered the material required for the segment timbering the next day. After being impressed by the crushing of the wall-plate and segment timbers, it was with considerable anxiety that the undermining of the wall-plate with the power shovel was attempted. The characteristic of the ground, of re-

*Abstract of paper read before the American Society of Civil Engineers.

maining firm for a short time after being opened up, was encouraging. As it turned out, the fear of loosening part of the tunnel by the side sliding in, while the wall-plate was carried on batter posts, was groundless. There was no settlement of the wall-plate of more than 1 in., and the work was hastened and cheapened by this method much more than by driving drifts to place posts before excavating the core of the tunnel. The excavation of this earth section was finished in December, 1914.

Pioneer Headings in General.—The pioneer tunnel, in rock, was 7 ft. high and 8 ft. wide. It was driven with light hammer drills, using hollow steel, with water attachments. Three drills, in general, but four in the

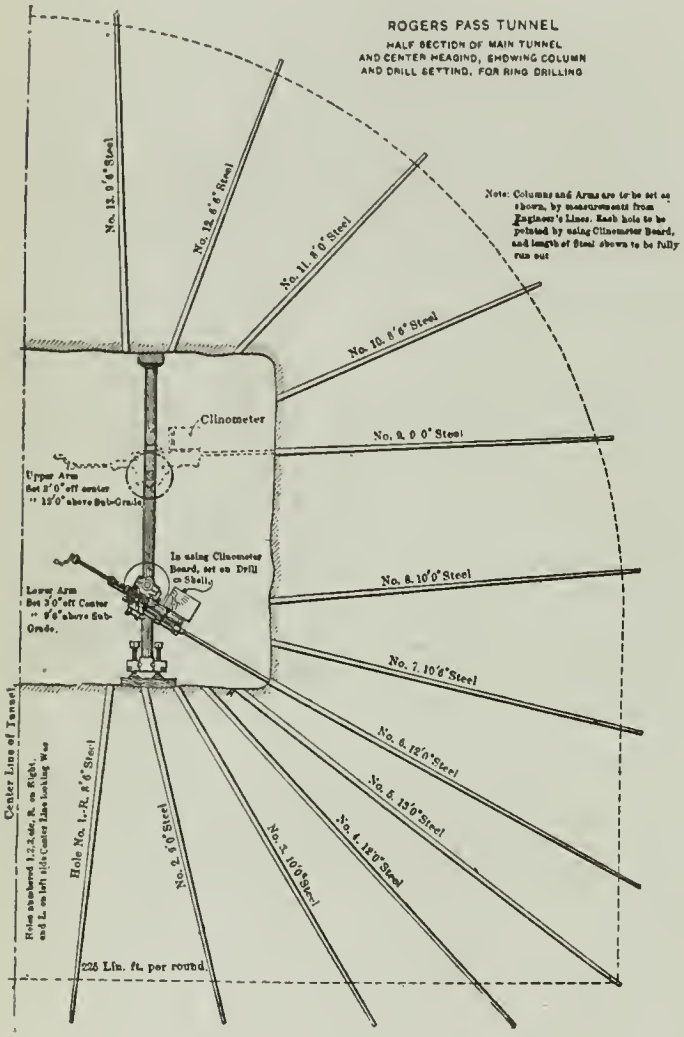

ROGERS PASS TUNNEL
HALF SECTION OF MAIN TUNNEL AND CENTER HEADING, SHOWING COLUMN AND DRILL SETTING, FOR RING DRILLING
No. 12, 6'6" Steel
No. 11, 8'0" Steel
No. 10, 8'6" Steel
No. 9, 9'0" Steel
No. 8, 10'0" Steel
No. 7, 10'6" Steel
No. 6, 12'0" Steel
No. 5, 13'0" Steel
No. 4, 12'0" Steel
No. 3, 10'6" Steel
No. 2, 9'0" Steel
No. 1, 8'6" Steel
Clinometer
Upper Arm
Lower Arm
Center Line of Tunnel
226 Lin. ft. per round.

Fig. 2.

hardest rock, were used in a heading. Spare drill machines, for the replacement of drills out of order, were kept conveniently at hand in the heading. No repairs were made underground. The hammer drills are convenient and rapid, the delay and expense of their constant breakage perhaps balancing the advantage of speed under ordinary conditions. The drills are mounted on a light horizontal bar, about 18 ins. below the roof line. Air and water are taken over the muck pile, or on hooks in the side, by a single hose line for each, to a manifold from which short individual hose lines supply the drills.

Light cars (½ cu. yd.) were used for muck, and the latter was taken off the track, instead of building sidings for this purpose. Shovelling plates were used at the face and on the side away from the track for some distance back of the face, in order to facilitate the handling of empty muck cars. The ventilating pipe was a 12-in. wooden water pipe connected to the Connersville blowers used for the exhaust. This pipe was hung on the side away from the track, close up to the roof and was carried to within 20 ft. of the face. Little damage was done to this pipe by blasting. The blowers were started exhausting when the first shot was fired, or a little before, and were run for 20 minutes. The men got back to work in from 5 to 10 minutes. No compressed air was allowed to be blown out for ventilating purposes. After a round was shot, the drillers followed the smoke back, barring down the roof, bringing explosives to re-shoot, and wetting down the muck pile, sides, roof, and face with water hose. The muckers cleared the track and began loading the muck which was scattered back.

When no further blasting was required, the lights were hung, the foreman sighted the line and grade point in the face, and the drilling gang set up the horizontal bar, placed their drills and proceeded. There was rarely any muck to be handled before the drilling could be started, as it was thrown back from the face by the heavy loading in the bottom holes and the fact that they were shot last, for this purpose. There were two helpers to three drills, and they brought up and changed the steel and adjusted the drill machines. When the drilling from the upper set-up was completed, the drillers took down the machines and carried them back, with the hose connections still attached, and oiled them up. After the mucking was done, the bar was dropped to the lower set-up, near the floor, and the drills were set to drill the bottom holes or lifters. The drills were carried forward, put on the bar, and were drilling sometimes in less than 2 minutes after the bar was dropped. While the bottom holes were being drilled, the muckers laid the track, adjusted and covered the mucking sheets with muck, and brought up the explosives. The holes were loaded by the machine men, helpers, and foremen.

For the small part of the tunnel where re-shooting was not necessary, an 8-hour shift could do two rounds per shift, or a little better. Two men pick down the muck, and three men load the car and push it out, while three others stand by with an empty car, ready to put it on the track and load it. The three men taking out the loaded car return near the face with an empty car, take it off the track, and rest until the load comes out. The men get a rest from the monotony of steady continuous shovelling, and the empty car is available at once after the load goes back. The pipes for ventilating, and for air and water were laid by a pipe man and helper, who looked after several headings.

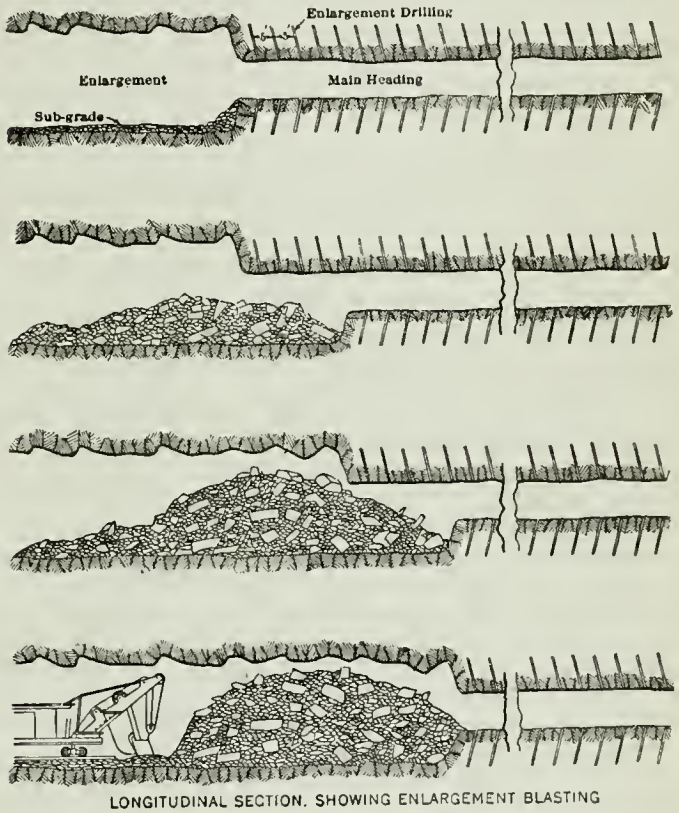
Doing this work with muckers was unsatisfactory. Muck cars were taken from the heading back to a siding by a single mule, and from there to the dump by a two or three-mule team driven tandem, until this method became inadequate, and then compressed-air locomotive haulage was substituted for the long haul. The heading muck cars, after the shovel and switching track had cleared a cross-cut, were taken to the cross-cut, pulled up an incline trestle by air hoist and cable, and dumped into standard-gauge cars. The cross-cuts are from 1,500 to 2,000 ft. apart. Air pressure was maintained at about 90 lbs. at the drills, which required 125 lbs. at the compressors toward the end of the work.

Main Heading.—The main heading, generally known on the work as the "Centre Heading," was entirely through the rock section. It was 11 ft. wide and 9 ft. high, the centre line being the same as that of the completed tunnel and the bottom being 6 ft. above the sub-

grade. The position and size were such that lateral holes could be drilled from this heading to break the enlargement to the required dimensions. The air, water, and ventilating pipes for this heading were branches from the mains laid in the pioneer heading. Access to this heading was obtained through the cross-cuts from the pioneer, and muck was handled around the enlargement operations by the pioneer route. This heading was generally driven in a westward direction, on account of the drainage. The system of driving was similar to that in the pioneer. The rounds averaged about 7 ft., and 32 holes were drilled in the hardest rock. The main heading was sometimes driven from several faces. The average daily progress per heading at the east end was slightly more than 16 ft., and the maximum monthly progress was 621 ft. The average daily progress per heading at the west end was 20 ft.; the maximum monthly progress was 762 ft.

Enlargement.—Drilling: The enlargement drilling, after some experimenting, was done as shown by Fig. 2. Each hole was pointed by clinometer, the column carrying the drill being set always at the same distance off the centre line, and the arm for the lower and upper sets being always the same distance above the sub-grade. Line and levels were furnished by the railway company's engineers, and a string was stretched by which the columns and arms were located. Each drill hole had its proper distance from the arm. The drill holes were thus bottomed at a regular distance beyond the neat line of the completed excavation. The holes, being bottomed with reference to the line and grades given by the engineers, were not affected by irregularities in the heading driving. The columns were set by men for that purpose, so that the drillers and helpers had only to do the drilling. The drill steel was brought to the drillers, and the dull steel was taken away. The drillers and helpers were paid their wages in any event, but the footage for each man was kept, and if the price set per foot drilled amounted to more than his wages, he was given the difference as a bonus check. Air and water connections were made for every third ring of holes, and only one drill machine, though handled by each runner of the three daily shifts, completed the three rings, and then moved to the head of the line, taking the next three rings. Congestion of men and material was thus avoided, and each man had a fair chance to work on an equal quantity of hard and soft rock. There was extreme variation in the quantity drilled by different men and in different rock. The same man might do only 6 ft. a shift in the hardest quartzite, and more than 100 ft. per shift in the softer schist. New men, after a month's practice, generally made more footage than men of long experience in mining. In general, it was found better to train green men than to try to get men accustomed to piston drills to learn to run hammer drills. Most of the rings were 6 or 6½ ft. apart. When explosives rose in price it was found economical to space the rings 5 ft. apart, as the extra drilling cost was balanced by the saving in explosives, with the added advantage that the muck was broken into smaller pieces and scattered farther back. Where the roof was soft and full of slips, so that trouble was anticipated, the upper set of arms on the column was lowered 1 ft., in order to leave some trimming of the roof to be done by jack-hammer, flat holes and light blasting. The air and water for the enlargement drilling, as well as the supplies, came by the pioneer tunnel and the cross-cuts, so that this drilling was not disturbed by the enlargement blasting. The drilling for the last mile, where no pioneer tunnel was driven, was started at the middle and progressed toward the portal, the track, pipe, etc., being removed as the drilling was finished. The stopping of the pioneer tunnel was well-timed, as the main heading was driven and the enlargement drilling completed just in time to avoid delaying the enlargement blasting and mucking at the east end.

Generally, from ten to fifteen rings were kept loaded ahead. Any part of a hole which had not broken, and could be found, was reloaded and shot with the next ring. Generally, a little muck was left in the face by the power shovel in order to prevent the first ring from scattering back too far. If the previously shot material had not broken to the required width, however, all the muck was loaded, and jack-hammers were used to drill up this tight rock, after which it was shot before the regular rings were blasted. Several bottom rings were first blasted, then a top and bottom ring were blasted together until the muck piled up to within 4 or 5 ft. of the roof. Then blasting



LONGITUDINAL SECTION, SHOWING ENLARGEMENT BLASTING

Fig. 3.

was discontinued, and the men scaled and trimmed the roof, working from the muck pile. (Fig. 3.) Where no holes had to be reloaded, rings could be blasted at intervals of from 15 to 20 minutes. The blasting was done with a battery in the main heading, and the bottom holes were all loaded ahead, the wires being wound up and stuck in the holes, from which they could readily be pulled out and connected. The upper holes were loaded, but no primers were put in until ready to blast. The holes were loaded to within 4 ft. of the collar, whether sprung or otherwise.

Concreting.—About 1½ miles of the tunnel, including the soft ground at each end, required concreting. This work was sublet to the Bates and Rogers Construction Company, of Chicago and Spokane. The concrete section is heavily reinforced. The sub-contractors used wooden forms, and deposited the concrete from a platform near the roof reached by an inclined trestle. The concrete mixer was on a car, and the materials were on other cars back of it. The concrete from the mixer flowed into a

small car which was hauled by cable up the trestle incline to the high platform, from which it was shovelled into the forms. Much of the lining required back as well as front forms, and the space behind the back forms was filled with rock or wood. This back-form and back-filling work was slow and expensive, especially where there were only a few inches between the back forms and the rock. The concreting has been well done, but the work is behind time, owing largely to conditions which the sub-contractors could not control.

The tunnel has been finished 11 months ahead of the contract time, and for a substantial sum less than the price bid. There have been no strikes, or interruptions of the work. The management has had the necessary money and authority, and has been given a free hand, both by the railway company and the contractors, and has had the loyal support and valued assistance of the men.

The railway company did the necessary engineering work. Messrs. F. F. Busteed, H. G. Barber, and W. A. James, were successively in charge, Mr. J. G. Sullivan being chief engineer.

PILE-DRIVING AND THE SUPPORTING POWER OF PILES.*

By Henry Adams, M.Inst.C.E.

TWENTY-FIVE years ago the writer read a paper before the Society of Architects upon "Timber Piling in Foundations and Other Works." The notes then collected and since added to relate chiefly to timber piles, with which the writer has had considerable experience, and upon which much scattered information has already been published; but all driven piles, whatever the material, must behave more or less according to the same laws, and the knowledge gained concerning ordinary timber piles will be likely to enable us to discover the laws and regulate the practice of driving and using piles of other material, including reinforced concrete.

Driving Piles.—Ordinary piles are driven by what is called a "pile engine." It is virtually a large hammer, the weight being arranged to fall freely and strike a succession of blows upon the head of the pile. It consists of a tall framework, with vertical guides on the face to keep the hammer or ram in a direct line with the head of the pile. The base of the pile engine is placed just above the finished level of the pile head, so that in driving long piles a high framework is required. It is, however, sometimes impossible to get the framework high enough for this, and it is then set 6 ft. or 8 ft. above the finished level, and a punch, dolly, or follower, of hard wood, hooped at both ends, is used on the head of the pile when it gets as low as the base of the frame, but the blow is not so effective and the method should be avoided when possible; it is said to reduce the effect of the blow one-third, more or less, according to the rigidity of the material. The length of a pile is generally determined by the local conditions of site and soil, the sectional area chiefly upon the load it has to sustain, usually the ratio—

$$\frac{L}{A} = \frac{1}{4} \text{ to } \frac{1}{8}$$

but no general rule can be laid down, as it depends to some extent upon the unsupported length above ground.

*From a paper read at a meeting of the Concrete Institute held December 21st, 1916.

Pitching and Driving.—In pitching a pile care must be taken that it is started in the right place, as it cannot be shifted, but if the point is not truly in line with the axis of the pile, or gets pushed to one side by meeting an obstruction before it has entered very far, the lower end of the pile will be drawn over to the side to which the point leans. In spite of the greatest care they will sometimes be found slightly out of position, and they have then to be drawn back into place by chains, twisted like a surgeon's tourniquet, while being bolted to the other timbers. If it be necessary for them to be scarfed, the upper portion can be adjusted by cutting the scarf a little out of line to suit. All piles are not required to be vertical; in building jetties the outside row of piles is often doubled, the outer pile being a raking one, at 15 to 30 deg. from the vertical, for increasing the stability, acting like a buttress. At the corners of jetties the outer piles are usually raking both ways, say, about 15 deg. from the vertical. When necessity arises piles may be drawn from the bed of a tidal river by lashing empty barges to them and letting them lift by the tide. Against a river wall, or round the foundations of a bridge, piles should be sawn off by a diver as low as he can get at them in preference to drawing them, to avoid any risk of scour and undermining of the foundations taking place. On land a pile may be drawn by lashing a short piece to the top and then prising it up by another baulk used as a lever, or by a pair of powerful jacks.

Weight of Ram.—One of the most interesting questions in connection with pile-driving is the proportion between the weight of ram and the fall to produce a given result. The ram usually weighs from 5 cwt. to 30 cwt., and is allowed to fall, say, from 6 ft. to 20 ft. Upon a superficial consideration it would seem that a ram of 5 cwt. falling 20 ft. would produce the same result as a ram of 20 cwt. falling 5 ft., as they would both have 5 ft.-tons energy, but the proportion of the total energy ($W h$) which is usefully expended in sinking the pile depends *inter alia* upon the ratio of the weight of ram to the weight of the pile. Some of the total energy is always wasted.

A light ram with a long fall will not have the same effect as a heavy ram with a short fall. In practice it is found that with too great a fall the effect of the blow is to bruise and "broom" the head of the pile, or to shiver the timber instead of to force it downwards. A heavy ram, producing the same effect in distance driven as a light one with greater fall does less injury to the pile. Dobson says: "In working with a fall from 12 ft. to 20 ft. it is common for every tenth pile to be more or less shaken." Of course, he meant to say "one pile in ten." It is as if the top of the pile were driven down while the bottom remained stationary, owing to the inertia of the mass of the pile.

For the first few blows the pile goes down a considerable distance, which gradually becomes less at each blow until the resistance is so great that it will not go any further, or, as it is technically called, "refuses." Were the material of the pile perfectly rigid and inelastic, the impact, however slight, would produce an infinite pressure, but the material is very elastic, and so the fibres of the pile are compressed without the point going any further, and the amount of this compression and the elasticity are strikingly shown in the rebound of the ram when the pile refuses.

The Supporting Power of Piles.—The sustaining power of a pile depends chiefly upon three circumstances: (1) The resistance at the point or shoe to further penetration; (2) the friction of the earth on the sides of the

pile; and (3) the strength, as a column, of the pile above the ground or above the firm subsoil.

Although it would seem that these are simply elements, each of which could be fairly estimated, the complexity of the case is shown by the numerous formulæ which give results ranging up to about 450 per cent.

In Newman's "Earthwork Slips and Subsidences" the frictional resistance of timber piles is stated to be less through wet soils than dry, in the following proportions:

In sandy gravel, 5 to 10 per cent. less.
In sand, about 12 per cent. less.
In sandy clay or gravelly clay, about 40 per cent. less.

Experiments with cast-iron piles by McAlpine gave about ½ ton per square foot of surface as the supporting power from friction when sunk 20 ft. to 30 ft. in rocky gravel. He considers it would amount to 3 tons per square foot in fine earth, but this seems to be an extravagant assumption. In experiments made previous to the sinking of concrete piles for the works of the Vienna-Danube Sand Dredging Company in 1909 it was found that the frictional resistance was about 14.19 lbs. per square inch of surface = 2,054.36 lbs. per square foot, or just over 18 cwt.

G. B. Bidder was of opinion that "in clay or wet soils it was not advisable to trust a greater weight than 12 tons upon each pile, but in gravel there was scarcely any limit to their vertical bearing strength."

French engineers (*vide* Berg's "Safe Building") allow a pile to carry 50,000 lbs., provided it does not sink perceptibly under a ram falling 4 ft. and weighing 1,350 lbs., or does not sink ½ in. under thirty blows.

A common rule for safe dead load on each pile is 5 tons per square foot of cross-section in soft ground, or 1 ton per inch side of square piles in firm ground.

The New York Building Regulations permit a load of 20 tons per pile, but the size is not specified.

The writer believes they use Wellington's formula for safe load.

Haswell (Minutes of "Proceedings" of the Institution of Civil Engineers, cxv., p. 318) says: "In deciding upon a factor of safety in a formula for pile-driving, the following elements must be considered: The friction of the machine; the resistance of the atmosphere to the fall of the ram and the cushioning on the head of the pile, however square it may be dressed off; the want of verticality both in the fall of the ram and in the plane of the pile, and the consequent lateral vibration; the inertia; the vibration and condition of the soil. Were all the conditions known definitely and allowed for, a factor of safety of 2 would be ample, but as the formulæ do not take account of all the conditions a larger margin is necessary. In some ascertained supporting powers recorded by Trautwine they were found to be from 2.3 to 3.7 times greater than given by the formulæ.

There seems to be no general rule as to the factor of safety it is desirable to adopt; the practice appears to vary from 2 to 10, the former being suitable for dead loads and the latter for live or vibrating loads. Intermediate factors would be produced with varying proportions between the dead and live loads. Obviously, unless the ultimate resistance given by the formula is reliable, the resulting factor is unknown.

In Dobson's "Foundations and Concrete Works" (Weale's Series) we are told that "of the comparative effect of impact and pressure in driving piles we as yet know nothing, and the question is so complicated, from the great number of points that have to be taken into consideration in reducing the results of experiment into a definite form from which some rule for our guidance might be obtained, that we can only lay down in general terms the following empirical rule that in ordinary cases if a pile will safely resist an impact of 1 ton, it will bear without yielding a pressure of 1½ tons," and he gives Wv = impact, therefore safe load = $1.5\ Wv$.

Dobson is, however, wrong in his theory; he assumes that the force of a blow is measured simply by the product of the weight into the velocity, and this assumption leads him to conclude that a 1-ton ram with a fall of 16 ft. will have the same effect on the head of a pile as a 2-ton ram falling 4 ft., while the former takes double the expenditure of power to raise it. In other words, he says $f = mv$, instead of $ft = mv$, which is the well-known formula where f = force, t = time, m = mass = $\frac{w}{g}$ v = velocity —that is, a force f, acting for time t, will move a mass m, with a velocity v—but action and reaction are equal in magnitude but opposite in direction; therefore, a mass m moving with a velocity v, and expending its energy in time t, will produce a mean pressure—

$$f = \frac{mv}{t}.$$

Weight = product of mass into force of gravity, or $W = mg$, therefore

$$m = \frac{W}{g}, \text{ or } f = \frac{Wv}{gt}, \text{ instead of } f = Wv$$

as Dobson puts it. The same error is made by Molesworth, and a table of results is given assuming that the force of the blow varies as the square root of the fall instead of directly as the fall. The product mv gives the momentum in its original sense. It is also known as quantity of motion, but it cannot be compared with force or pressure unless time be taken into account.

A worked example will perhaps make this clear—

Let W = 0.25 tons, h = 20 ft., S = set at head of pile = ¾ in., then

$$v = \sqrt{(2gh)} = 35.7 \text{ ft. per second,}$$

but v varies from 35.7 to 0 while passing through the ¾ in., therefore mean $v = \frac{35.7}{2} = 17.85$ ft. per second, and ¾ in. = 1/16 ft.; therefore time occupied in passing through ¾ in. = 1/(17.85 × 16) = 1/285 of a second. Then by formula—

$f = Wv/gt = (0.25 \times 35.7/32\ 1/285) = 79.5$ tons but if the exact fraction be taken it will give 80 tons mean pressure. By formula—

$$Wv^2/2g = Wh = 0.25 \times 20 = 5 \text{ ft.-tons,}$$

or a mean pressure of $\frac{5}{1/16} = 80$ tons, as before.

It will be observed that S is taken as the set of the head of the pile, and attention must be directed to one very important point. The distance the head of the pile moves after being struck is the criterion of the resulting force in pounds, but only part of this force is returnable as supporting power; some of it is expended in compressing the pile, and any formula that does not take account of the compression of the pile as well as the penetration of the point can only be approximately true. The resistance at the head of the pile begins at zero and terminates at such a pressure that the total movement multiplied by the average pressure equals the foot-pounds energy of the blow.

The test of a pile at Royal Victoria Dock, London, is recorded in "Engineering," December 29, 1899, p. 826, as follows:—

Pitch-pine pile, 12½ × 11½ = 143.75 sq. ins., 37 ft. long = 36.8 cu. ft., at, say, 50 lbs. per cu. ft. = 1,840 lbs. Weight of ram = 12 cwt. = 2,016 lbs.

Driven in peaty ground a distance of 36.1 ft., going 2¼ ins. to four 8-ft. blows when driving was stopped.

Loaded with rolled joists balanced on head.

Load 10	tons	No sinking	Remained thus	24	hours
" 20	"	1/16 in.	"	48	"
" 30	"	1/16 in.	"	0	"
" 37·5	"	3/16 in.	"	7	days
" 56.9	"	¼ in.	"	4	weeks

No further sinking. Load being removed, pile rose 3/16 in.

The rising of the head of pile when the load was removed showed the amount of temporary compression in the timber, and the missing 1/16 in. may have been further compression held back for a time by the friction of the earth, at the sides, and possibly reappearing some time later, a sort of *hysteresis*. The result of the test shows that the pile was practically safe with a load of 60 tons, but, like other tests that stop short of completion, it did not show that it would have failed with double the load or more.

The sort of test that is required to prove the accuracy of any formula is to measure the distance moved by the head and by the point during, say, the last four blows, and take the average for each. Cut off a foot from the top of the pile to receive the load on a good surface. Carefully level through from a fixed bench mark to find the level of the top of unloaded piles. Calculate the safe load on the pile and load it up until the head of the pile has sunk to the amount to which it was previously compressed (*i.e.*, previous average movement of head—average movement of point); note this load. Then continue loading, and note level of pile at each ton addition until the head of the pile has sunk, say, double the previous compression—*i.e.*, previous average movement of head, minus average movement of point. Then leave it loaded for twenty-four hours, and note whether it has sunk further and how much. Remove the load and note the result.

The difficulties in the way are: (*a*) Finding enough load; (*b*) supporting the load on the pile without friction; (*c*) measuring the results accurately; (*d*) avoiding personal danger throughout the test.

Reinforced Concrete Piles.—The advantages of reinforced concrete piles are so manifest that they need no express recommendation here. The chief physical differences from timber piles, as regards driving and their supporting power, are due to their extra weight and their friable nature. They should be made with slow-setting cement six weeks before driving, but if made with quick-setting cement they must be left eight weeks, because in the latter case the outside hardens first and leaves the interior soft. They should be driven by steam or drop hammer with a 3-ton ram, having a fall of 3 ft., with a steel helmet filled with sawdust, and preferably without a dolly.

In America the use of a water jet is found to greatly facilitate the sinking of concrete piles.

Hollow cylindrical reinforced concrete piles have been used at Southampton, Newcastle-on-Tyne, and Liverpool. They are lighter and cheaper than solid piles and more effective. Those at Brockelbank Dock, Liverpool, were 20-in. diameter. Reinforced concrete piles of circular section are easier to drive than square piles, and as they have no sharp angles are less liable to be damaged by coming into contact with boulders, etc.

As reinforced concrete piles are made horizontally, care must be taken in lifting them; the points of attachment for lifting should not be less than half the length apart, and if lifted with one end on the ground the attachment should be one-third the length from the other end.

The reinforced rods (about 2½ per cent.) should preferably be hooked at the top and electrically welded together at the bottom. They should be bound helically by, say, ¼-in. wire, 4-in. pitch, carefully secured at the top.

REPORT OF COMMITTEE ON RECOMMENDED PRACTICE FOR STANDARDIZATION OF FILTERS.

SOME years ago (May 12th, 1913) the American Society of Mechanical Engineers upon the suggestion of Mr. P. N. Engel appointed a committee to investigate and report on how to rate the capacity of mechanical filters.

This committee, of which Geo. W. Fuller, of New York, was chairman, has now presented its report and this, together with some discussion on it, is printed herewith:—

Your committee, appointed to make recommendations as to how to rate the capacity of mechanical filters, desires to submit the following report:—

Municipal vs. Industrial Field.—(2) The field of mechanical filtration may be arbitrarily yet definitely divided into two parts: One, the purification of drinking water or water for domestic supply, and the other the purification of water for other purposes, such as industrial uses.

Municipal Practice Substantially Uniform.—(3) On account of its importance and the large expenditure involved, especially in connection with municipal plants, much time and study have been given to all features of the filtration of water for domestic use. A large amount of data gathered through laboratory tests, and experience covering long periods in the practical operation of municipal plants, have brought into quite uniform adoption by all engineers engaged in such work the use of a rate of filtration of 2 gal. per min. per sq. ft. of filtering area for domestic supply.

Departures from Normal Municipal Rate Permissible.—(4) While stating as a matter of information that such a rate is applicable in the great majority of such cases, your committee does not feel warranted in setting forth this rate as one to be adopted for all cases. As a matter of fact, the installation of a municipal filtration plant usually is done, and always should be done, under the advice and supervision of a competent filtration engineer engaged for the purpose, and the rate of filtration as well as other points of construction and operation should be left to his judgment, based upon the local conditions that may exist. For this reason, your committee feels that it is advisable and in accordance with the spirit and intent of your instructions to refer herein chiefly to the filtration of water for other than municipal purposes.

Various Views Canvassed.—(5) Your committee in considering this subject has sought information and assistance from many sources, and we desire herewith to express our appreciation of the many courtesies extended to us by those thus called upon for data or comment.

Gravity vs. Pressure Filters.—(6) It may be well here, in view of the misunderstanding that seems to exist

to some extent, to make some reference to the two different types of mechanical filters known as the gravity type and the pressure type. With both types, purification is accomplished by passing the water through a filtering bed, which in practically all cases is sand, and the purification is dependent upon the property or power of the bed of sand to remove suspended impurities from the water passing through. This property is one inherent in the filter bed itself, and, while it will be affected by the rate at which the water passes, it is not altered by the incidental fact of the water being or not being under more than atmospheric pressure. While, with additional pressure available, more water can be forced through a pressure filter than a gravity filter of given size, there is no difference in the principles or methods employed that warrants a higher rate of filtration with such filters than is acceptable for open or gravity filters when similar results are to be obtained.

Experience Leading to Standardization.—(7) From the information gathered it was made apparent that experience has already brought about a substantial unanimity of opinion and practice on the part of all those who, as engineers, chemists or manufacturers, are brought into close contact with the field of mechanical filtration as to the limits within which permissible rates of filtration must fall. A very definite rate has become established in connection with municipal work, and indeed if there had been anything like the publicity in connection with filtration of water for other purposes that has obtained in connection with gravity filters such as are installed for municipal work, it is probable that there would have been no occasion for such investigation and report as this committee has been called upon to make.

Tendency to Over-rating.—(8) While our investigation has made the above situation apparent, it has also developed the fact that there have been many filters installed in which the rate of filtration per unit of area is beyond, and sometimes far beyond, that at which good results can be expected or required. In some cases this has been due to the specifications under which the filters were installed, and in others, to what must be called an over-rating of the capacity of filters on the part of manufacturers. It is easily possible to force or pass through a filter of given dimensions much more water than it will properly filter, and in view of this it must be expected that there will be more or less yielding on the part of manufacturers placed under competitive conditions to the temptation to over-rate their filters.

Need for Definite, Reasonable Specifications on Capacity.—(9) This condition emphasizes the need and value of a pronouncement on this subject by some such body as the American Society of Mechanical Engineers which will serve for the information and guidance of those who, while having occasional need to specify or use mechanical filters, do not have opportunity to keep fully informed of conditions in that field. It is, therefore, hoped that this report and its recommendations will be of real value to engineers by placing before them information as to what is now the best opinion and practice, and thus enabling them to protect their own work and their clients' interests. To this end your committee most heartily and urgently recommends that when specifying filters there be included not merely the amount of water to be filtered per unit of time, but also specifications as to the rate of filtration per unit of area, or else the area or dimensions of the filter bed. Specifications thus written will insure fair competition and more satisfactory results.

Identity in General Design.—(10) The same general design and the same principle of operation are followed by all the leading manufacturers of mechanical filters, the filtration being downward through a bed of sand superimposed upon layers of gravel, the filters being washed by a reverse flow of water. Competition in construction is, therefore, limited to the excellence of materials and workmanship, to the perfecting of details and to adaptations for convenience in accordance with good filtration engineering practice. While this affords abundant opportunity for conscientious care and requires familiarity with the history of filtration and thorough knowledge and observance of the results of experiments and tests, it does not allow any application of ingenuity to change fundamental requirements that are dependent upon natural laws.

Unnecessary to Standardize Construction Details.—(11) Your committee feels that it would be unwise, at least at this time, to attempt to standardize details of construction, there being a wide range in this field for individual preference or convenience, but there may well be established a standard in regard to the rate of filtration, since the object thereby sought is not mere uniformity but compliance with the limitations imposed by the laws of nature, so that the possible benefits of filtration will be actually and fully realized. It would thus seem to be self-evident, even if it were not fully established by experiment and experience, that the capacity of any filter is dependent upon and determined by two factors: (*a*) The permissible rate per unit of area at which the water can be passed to insure the desired results; (*b*) the effective area of the filter bed.

Agreement Among Leading Filter Manufacturers.—(12) It was made evident by the data gathered that there is a unity of opinion on the part of those best qualified to judge at what rate water may be passed per square foot of filter area to secure desired purification, and that there is a close agreement in the practice of all the leading filter manufacturers in rating the capacity of a filter.

Form of Expressing Capacity.—(13) For convenience, we have expressed the rate of filtration in terms of gallons per square foot of superficial filter bed area per minute, thus combining units of quantity, area and time in a way to make easy the calculation of the amount of water any given filtering unit will properly handle or to estimate the area of filter bed surface that will be required for a given supply. The filtering area should be computed on the upper surface of the filter bed, as the latter lies during normal filtering operation, and no attention should be paid to a greater cross-sectional area such as is sometimes found in horizontal cylindrical filters.

Care as to Maximum Demand.—(14) In deciding upon the size of filters to be installed in any instance, very careful consideration should be given to the maximum flow that will be required at any time, and ample capacity provided. Where the demand is irregular, the maximum requirement is much greater than the average or minimum consumption, and either adequate storage for filtered water should be provided or the rated capacity of the filter made equal to the maximum demand. All filters are capable of passing more than their rated capacity, but beyond certain fairly narrow limits this is always at the expense of the quality of the filtered water, unless more than ordinary care is taken in efficiently coagulating the unfiltered water. As already intimated, the persistent use of moderately high rates above the normal and the occasional use of excessively high rates should be discouraged, if not prohibited.

Depth of Filter Bed.—(15) While in a sense consideration of the filter bed may not be included within the instructions given your committee, we feel that some re-

marks in this connection will be of value, especially as there seems to be an opinion in some quarters that the use of a thicker filter bed or special methods or appliances for washing, or similar features, make higher rates of filtration permissible. In regard to such points, we would say, that while of course there is a minimum thickness of filter bed that must always be maintained for safety, better results do not follow increased depth. In fact, an excessive depth of sand bed is in some instances objectionable, as it may interfere with proper washing. We find that the minimum thickness of filter bed should be 27 ins., of which at least 18 ins. should be sand or similar fine material. A filter-bed thickness of 33 ins., of which at least 24 ins. is sand or similar fine material of suitable size and grade, is recommended.

Influence of Filter Washing.—(16) While efficient washing of the filter bed must be provided for and while the use of special means or appliances, such as stirrers, air agitation or other means of breaking up the filter bed, may be of value in some cases as means of securing economy in time or of water consumed in washing the filter bed, the direct effect of such means is limited to that secured during the washing process and such effect has no influence one way or the other on the permissible rate of filtration, which is dependent upon and limited by properties inherent in the filter bed itself.

Normal Filtering Material.—(17) The most desirable filter medium is a granular substance of a hard, non-porous, insoluble character, with grains substantially uniform in size and shape, the exact size and uniformity of the particles being open to some variation depending upon local conditions. If properly washed, such a filter bed will remain in efficient working condition for several years.

Special Filtering Material.—(18) Bone charcoal or other porous material is sometimes of aid in the removal of iron, color, tastes or odors. But if they are used it must be recognized that growths of bacteria in the effluent are very likely to occur, although there is no evidence to indicate that such growths include disease-producing germs. These porous media may be used in single or double filtration, as noted in Pars. 20 to 23, inclusive.

Recommended Rate of Filtration.—(19) The permissible rate of filtration in any instance depends upon the character of the water to be filtered and the purpose for which the water is used. If the water is for domestic purposes, whether the filters are installed in a municipal plant or otherwise, the rate of filtration should not exceed that which has been adopted for such service by universal consent of filtration engineers. We therefore recommend that: (*a*) Whenever the water is to be used for domestic purposes or to secure full bacterial purification, the capacity shall be based upon a rate of filtration not to exceed 2 gal. per min. per sq. ft. of filtering area and a coagulant must be used. (*b*) Where a lesser degree of purification is required, either because the water is not to be used for domestic consumption or because the water to be filtered is already sufficiently free from bacteria, or where the filtered water is to be effectively sterilized, a higher rate of filtration may be used, but not to exceed 3 gal. per sq. ft. per min.

Double Filtration in Special Cases.—(20) Your committee finds that there is a limited use made of double filtration; that is, the water is passed through two filters placed in tandem. The consensus of opinion of those consulted and the recommendation of your committee is that when both filters are filled with the same medium this is not the best practice, but that better results will be obtained from the same filters operated in parallel, if they are properly constructed, owing to the slower rate of filtration.

(21) Double or tandem filtration may, however, be used to advantage under some special circumstances, as, for instance, where the filter medium in the second filter is of a very close texture, so as to secure the very highest quality of filtered water by removing fine suspended matters that may pass through an ordinary filter bed.

(22) Double filtration may also be of advantage where the use of a coagulant is not desired or where it is intended to remove iron, color, odor or taste. In such cases sand can be used in the first filter and bone charcoal or similar porous medium in the second. Such practice, however, should be limited to cases where an increase in the numbers of harmless water bacteria, such as frequently occurs in the effluent of a porous filter medium, is not objectionable.

(23) If double filtration is employed, the rate of filtration should not exceed the rate of single filtration, unless warranted by the results of experiments or upon the advice of a competent filtration engineer.

Sterilization.—(24) In earlier years it was frequently the custom to sterilize filter beds with steam, but it was found that the benefit of this treatment was temporary, and it frequently resulted in the growth of water bacteria within the filter. At present, sterilization is normally and preferably secured in the filtered water through the aid of liquid chlorine, hypochlorite of lime, or ultra-violet rays. When properly applied, such treatment will destroy all objectionable bacteria.

Preparatory Treatment.—(25) While this report deals essentially with filters themselves, it is proper to point out that mechanical filters, with the rapid rate of filtration employed, cannot be expected to accomplish the best obtainable results without the securing of proper coagulation; and if the raw water is very turbid, then preliminary sedimentation also must be considered.

(26) In closing this report the committee desires to express its deep loss in the death on August 7, 1915, of J. C. W. Greth, Mem.Am.Soc.M.E., one of the original members, and also its appreciation of his aid in collecting data on the practical state of the art and of his judicially expressed opinion as to the basis of this report.

Discussion.—Jos. W. Ellms: The recommendations of the committee making this report are in agreement with the best modern practice in the design of mechanical filters. They have quite clearly indicated the maximum limits for safe rates of filtration and the minimum depths for the filtering medium. Their conclusions on these points are in accord with the writer's own experience.

In declining to commit themselves in regard to construction details, they are probably justified; yet it might have been well to have enunciated some of the general principles which experience has shown to be essential to the best design. The writer has reference more particularly to underdrain, strainer and waste-trough design. Probably no portions of a mechanical filter are more directly dependent upon proper co-ordination than are those whose principal functions relate to the cleansing of the filter bed. So far as these portions of the filter act as distributors of the influent water to the filter bed, and as outlets for the effluent from the bed, their importance is only of a secondary character.

It is of the utmost importance that the underdrain system of a filter bed shall effect as uniform a distribution of wash water as possible. Whether this is done largely through strainers of various types or through perforated pipes, or in conjunction with the coarse filtering material

forming the bottom of the filter bed, is of small consequence, so long as it is actually accomplished. Moreover, a uniform and speedy withdrawal of the dirty wash water by means of properly disposed waste troughs is as essential as uniform distribution of the wash water when entering the filter bed. In other words, a mechanical filter which cannot be quickly and effectively cleansed is defective.

It is to be hoped that the indorsement of the committee's report by the Society will establish certain definite principles of filter design to which manufacturers will conform, and by which purchasers of filters may be guided in judging of the merits of any particular design that may be submitted to them.

George A. Johnson: The report of the committee recommending certain standard procedures in filter practice shows clear evidence that the general proposition has been viewed from the numerous necessary angles and the tentative conclusions drawn from approved practice in filter design and operation. At best the preparation of such a report was a difficult task, for the reason that in water-filtration problems local conditions govern so very largely, and their individual peculiarities are so numerous and varied. This report will serve a valuable purpose in the development of standard practices where possible of application, and the committee is to be congratulated for the skill and conservatism displayed in its preparation.

AMALGAMATION OF McGRAW PUBLISHING CO. AND HILL PUBLISHING CO., OF NEW YORK.

The McGraw Publishing Co., Inc., and the Hill Publishing Co., of New York, have merged. The name of the company will be the McGraw-Hill Publishing Co. James H. McGraw will be president, E. J. Mehren vice-president and general manager, Arthur J. Baldwin vice-president and treasurer. All the papers owned by the two companies will continue as before, except "Engineering News" and "Engineering Record." These two papers will be merged and known as "Engineering News Record," with Charles Whiting Baker as editor and William Buxman business manager.

The new vice-president and general manager of this important combination of publishing houses has done remarkable work since he entered the field of technical journalism. In the minds of those who know E. J. Mehren there is no doubt at all that in this new connection he will, as he always has in the past, demonstrate his fitness for increased responsibility. Mr. Mehren graduated from the University of Illinois in 1906 and joined the staff of "Engineering Record" the following year as associate editor. Six years later, or in 1913, he became editor and under his care "Engineering Record" has shown remarkable editorial development.

In 1916 Great Britain led in shipbuilding with 510 vessels of 619,000 tons. The United States was second with 1,213 vessels of 560,000 tons. Ships built by all other countries numbered 782, of 720,368 tons. Loss to the world's merchant shipping in 1916 through war causes exceeded the total tonnage constructed, according to estimates prepared by the Federal Bureau of Navigation, Washington, D.C. Vessels sunk are put at 1,149, of 2,082,683 tonnage, and those built at 2,506, of 1,890,943 tons. The net reduction was about 200,000 tons, or one and one-half per cent. of the world's total. These figures were gathered from many unofficial sources, but are declared to be approximately correct.

LETTER TO THE EDITOR.

The Quaker Oats Fire.

Sir,—Doubtless many of your readers will be interested in the following facts which are the result of an investigation by the writer following the recent fire at the Quaker Oats plant at Peterborough, Ont.

Below are given some of the records of the investigation, the conclusions drawn, together with a few general remarks and suggestions with regard to fireproofing.

The concrete was badly cracked. The aggregate was gravel. I found when breaking up pieces that many of the smaller as well as of the larger aggregates had a soft layer of varying thickness, (1 to 3 m/m). Some were only partly covered with it. On closer inspection it became evident that these layers were formed from the surface of the stones themselves, and that they were not, for instance, coatings of clay or other foreign material. I picked out some of the aggregates which had these peculiar formations. The coatings were scraped off and analyzed, (see No. 4965). The stones themselves were afterwards ground up and analyzed, (see Nos. 4964, 4966, 4967).

I found, also, in some parts of the concrete, stratified layers of some fine material. A sample of these was collected and analyzed.

Analysis of Aggregates from the Concrete.

	No. 4964.	No. 4966.	No. 4967.
Volatile matters	39.69%	42.56%	41.53%
CaO (lime)	50.64%	54.42%	52.26%
MgO (magnesia)	0.77%	0.58%	0.74%

From these results we see that the damaged aggregates were composed of limestone.

Analysis of the Coating Scraped Off the Above Tested Aggregates.

	No. 4965.
CO_2 (carbonic acid)	25.21%
CaO (lime)	54.32%
MgO (magnesia)	0.86%

The composition of the material is therefore:

CaO, CO_2 (carbonate of lime)	57.29%
CaO, H_2O (slacked lime)	29.38%
MgO, H_2O (hydrate of magnesia)	1.25%

The layers covering the aggregates contained, therefore, considerable amounts of hydrated lime. This was evidently formed in the following way:

The heat from the fire burned the surfaces of the limestone aggregates to quick lime,

Limestone.		Quick lime.		Carbonic acid.
CaO CO_2	=	CaO	+	CO_2.

This, on the other hand, (CaO) was afterwards slacked to hydrated lime,

Quick lime.		Water.		Hydrated lime.
CaO	+	H_2O	=	CaO H_2O.

Part of the lime was slacked when the firemen poured water on the building, and the rest was gradually formed by absorbing moisture from the surroundings. It is, however, of minor importance for the final results in whatever way the hydration took place. The main thing is that when quick lime is slacked the resulting hydrated lime occupies a volume twice to three times as large. The

force with which this expansion takes place is so great that it is sometimes utilized for blasting purposes. I found, also, that wherever cracks appeared in the concrete the limestone aggregates were at least partly covered with a layer containing hydrated lime. It is, therefore evident that the cracks in the concrete were in these instances caused by the expansion, which took place when the quick lime formed by the fire was hydrated. The loose structure of the concrete was at least partly due to the same cause. But even the formation of a thin layer of quicklime round the aggregates must injure the concrete, as we know that this substance is much softer and weaker than the limestone. It would in this state act in a similar way as a coating of clay. The concrete would therefore from this cause alone be liable to break down during the fire, without any hydration taking place.

The kind of limestone found in the concrete will burn at about 1,490° F. (810° C.), wherefore the temperature in the effected concrete must have reached at least that point.

It is therefore evident that gravel containing limestone of a similar composition (the approximate B.T.U. was in this case = 7,800) should not be used where a possible fire of the combustible materials, stored in a building, will be able to raise the temperature in the vital concrete construction up to or above 1,490° F. For aggregates containing magnesia limestone the temperature limit is still lower. The poorer the limestone the easier will it "burn," but the less is the expansion when it hydrates. If the aggregates in this special case had been of a silicous character, as, for instance, granite, trap or other similar substances, the concrete would have, without doubt, withstood the fire, if not of too long duration.

The thermal value of the main part of the material stored in the building was found from actual test to be 8,092 B.T.U.

It was pointed out above that the loose structure of the concrete was due to the expansion caused by the hydration of quick lime. I found, however, indications that the concrete had been worked too wet. We know, however, that too much water will weaken the structure and make it porous and less able to take care of the different stresses. The above-mentioned strata found point to a mixture too high in water. The analysis of them gave the following results:

No. 4968.

Volatile matters	18.21%
SiO_2 (silica)	19.00%
Al_2O_3 (oxide of aluminum)	6.88%
Fi_2O_3 (oxide of iron)	1.43%
CaO (lime)	50.83%
MgO (magnesia)	2.32%
SO_3 (sulphuric acid)	1.29%

The composition of this material in the dry state would be as follows:

Volatile matters	1.46%
SiO_2 (silica)	22.84%
Al_2O_3 (oxide of aluminum)	8.29%
Fi_2O_3 (oxide of iron)	1.72%
CaO (lime)	61.24%
MgO (magnesia)	2.79%
SO_3 (sulphuric acid)	1.55%

From the analysis we may draw the conclusion that the stratified material was Portland cement. This circumstance indicates, also, that the mixing of the concrete might have been done better.

Porous and weak concrete is also caused by lack of cement. In this special case I do not know of any method by which we can determine the proportions of cement to aggregates. I analyzed the concrete and the results are:

No. 4983.

H_2O (organic matters)	4.10%
CO_2 (carbonic acid)	23.18%
SiO_2 (silica)	22.18%
Al_2O_3 (oxide of aluminium)	5.45%
Fi_2O_3 (oxide of iron)	1.56%
CaO (lime)	41.04%
MgO (magnesia)	1.34%
SO_3 (sulphuric acid)	0.24%

The CaO factor = 4.82 cc n/2 HCl.
Sp. gravity, 2.6211.

The only conclusion I can draw in this special case is that the concrete mixture was poorer than 1:6. I may add that, estimating the proportions from three different points of view gives the same result.

From the results obtained in the above outlined investigation I draw the following conclusions: The concrete suffered from the fire because the limestone aggregates were on their surfaces through the comparatively strong heat changed to quick lime, and this in its turn was hydrated when acted upon by water. The resulting great expansion caused the cracks and the loosening-up of the concrete.

In connection with this subject I may be allowed the following remarks and suggestions, based on the above findings:

There is in the public mind a rather uncertain idea as to the property of a fireproof structure. Some seem to think that it is fireproof if the materials in the same are not subject to combustion and others, that they must not only be inflammable, but that they should also endure fire from other materials without injury. There is, however, no building material in general use that is immune from the intensity of heat possible from combustion. The second definition in its fullest meaning must therefore be thought of more as an ideal than a practical possibility. The first view, on the other hand, includes some building materials which, while they do not burn are easily damaged by fire. Would it not, therefore, be well to go between the two and consider them as the lower and upper limits? Looking at the subject from this point, a fireproof building would be a construction of non-combustible materials that will endure the influence of fire up to a certain limit without being damaged. The limit or degree of heat it might be called upon to withstand will depend on the nature and quantity of combustible materials stored inside the same or in its immediate surrounding, and may therefore be estimated beforehand by the architect. By approaching the subject from this point of view the meaning of the word "fireproof" becomes more elastic and assumes an appropriate degree of individuality for each special case. It gives an adequate protection to the owner, and it will also serve to prevent useless expenditure, as the most suitable material can in each instance be selected to fit that special case.

Concrete has in many a fire proved its good qualities, and it would have done the same in this special case if the proper aggregates had been selected to suit the probable conditions.

Hoping the above will serve a good purpose.

A. G. LARSSON, C.E.

St. Mary's, Ont., February 12th, 1917.

Editorial

STANDARDIZING WOOD BLOCK PAVING SPECIFICATIONS.

Last year a committee was appointed by the American Wood Preservers' Association for the purpose of collecting and compiling all specifications and definitions covering wood block paving and to recommend such revision as may be necessary and present for insertion in the Manual. This committee was furthermore instructed to prepare a specification for the treatment and laying of creosoted wood blocks. The committee confined its specifications to the superstructure of a roadway or floor and included the surfacing of the substructure, the cushion, the blocks and filler.

It had on it representatives of the following associations: American Wood Preservers' Association, American Society of Municipal Improvements, American Society for Testing Materials, American Society of Civil Engineers, American Railway Engineering Association and the Southern Pine Association. The object was to endeavor if possible to have the committees who were working on wood-block paving specifications present identical specifications to their respective associations. In this success was attained, the members of each of the committees agreeing to present identical specifications on timber, size of blocks, treatment, handling after treatment and inspection.

The adoption by these various associations of uniform specifications is undoubtedly a step in the right direction.

THE PUBLIC AND THE HIGHWAY ENGINEER.

The season of the year is here when the many problems connected with the design, construction and maintenance of our highways force themselves upon those who are directly and indirectly concerned.

During the next few months a number of organizations, the principal object of which is to further the interests of good roads, will hold their annual meetings.

This week the Ontario Good Roads Association is holding its annual meeting in Toronto. At this meeting representatives from all parts of Ontario gather and discuss various phases of highway engineering.

From March 27th to 30th inclusive, under the auspices of the Ontario Department of Highways, a most important conference will be held. This conference will concern itself more specifically with the administrative and practical side of road building and is bound to be of great assistance to all those engineers and superintendents who are fortunate enough to be present and take part in the discussions.

The Fourth Canadian and Dominion Congress is to be held at Ottawa from April 10th to 14th inclusive. This convention, in turn, whose object is the spreading of the gospel of good roads, makes its appeal to a wider circle, attracting delegates from practically all over Canada and also the United States.

It is gratifying to find such an intelligent interest being taken in the work of such organizations as those named. They do a general educational work and make a real contribution toward a more intelligent and genuine spirit of co-operation between the layman and the highway engineer who is more directly concerned with the actual design and construction of the roads.

Highway engineers, because of the nature of their work, are brought more prominently before the public than engineers engaged in many other lines. At least it is probably true that more people are interested in road work than in the majority of other public enterprises, for the reason that all have occasion to use the highways. The condition of the roads in any community is generally a matter of personal concern.

The work of the highway engineer is more often the subject of discussion than are other branches of engineering. Such discussion is not always intelligent and there is much need for a great deal of activity on the part of highway engineers and organizations such as those referred to, in bringing this branch of engineering work before the layman in such a way as to make clear some of the points upon which he might be better informed.

Whatever can be done in the direction of molding public opinion to support wise plans and defeat unwise ones will be a service to the public as well as to the profession of highway engineering.

WORK OF THE ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

The Advisory Council for Scientific and Industrial Research, of which Dr. A. B. Macallum is chairman, has just issued a very important review of the subject, following a conference which was recently held in Ottawa. Some forty projects, each bearing on vital phases of scientific conservation and development of Canada's natural resources, have been submitted to the council.

Some of the larger projects now in view include a comprehensive industrial census, the training and utilization in industrial establishments of "efficiency experts," the creation of technical laboratories under State co-operation at the great industrial centres to give free help to manufacturers in solving their problems, the utilization and development of the latent fuel resources, particularly of the Prairie Provinces, and the preservation of the diminishing timber resources of Eastern Canada.

The council will issue questionnaires to the manufacturers, the technical societies, the various government departments, and the universities of the Dominion, asking for information with reference to the laboratories and various other agencies of research now in operation in the Dominion; the men now engaged in or available for research work; the raw materials required for our industries; the by-products produced but not at present utilized; and other matters required in the development of its work. In securing this information the council will work in close co-operation with the manufacturers' associations and the various technical societies of the Dominion. It is expected that the replies to the ques-

tionnaires will show many lines along which the council may assist in the development of Canadian industries.

The council will recommend the establishment of twenty or more studentships and fellowships in our universities and technical schools, which will be given to men who have completed their regular course of study and have displayed a special aptitude for scientific research. These will enable such men to pursue a course of advanced work at college for a further period. Arrangements will also be made by which men after graduation will be placed in one or other of the great manufacturing establishments of the Dominion, where they will continue their training under the conditions of actual commercial practice.

In order to furnish direct assistance to the manufacturing industries of Canada at once the council is recommending the establishment at certain of the great industrial centres of the Dominion, such as Toronto, Montreal and Winnipeg, in co-operation with the Provincial Government or other bodies, of Industrial Research Bureaus, where a complete set of technical magazines and trade journals will be found, and where technical staffs, provided with suitable and properly equipped laboratories, will assist the manufacturers of the district in solving problems which present themselves in their factories or works.

In addition to these broad general movements for the advancement of the industries of the Dominion, the council has decided to examine carefully a number of specific projects which have been submitted to it, and which appear to give promise of yielding valuable results. Among these latter one may be mentioned.

This has for its object the provision of an adequate supply of good fuel for the western plains, more especially in the provinces of Saskatchewan and Manitoba. There are in the former province large supplies of lignite. This is an inferior fuel, possessing a relatively low heating power, and which, furthermore, will not stand shipment and storage. It is, therefore, of comparatively little value for domestic or manufacturing purposes. The council, however, believes that by a special treatment there may be produced from this lignite two grades of high-class briquetted fuel, one similar to anthracite or hard coal in character, and the other resembling soft coal in general character; and at the same time certain very valuable by-products may be secured. The Department of Mines and the Commission of Conservation have already carried out a good deal of investigation in connection with this problem, and the former department is now making some further studies for the council. If they give satisfactory results, the council will advise that an experimental plant to turn out this high-grade fuel on a commercial scale be erected, and the possibility of producing this fuel at a cost considerably lower than that at which coal from the United States is now laid down in Manitoba and Saskatchewan be demonstrated on a large scale and the coal actually placed on the market. With an abundant supply of good, cheap fuel, the conditions of life on the great plains in winter will be much improved.

A report has been circulated to the effect that the plant of the S. Morgan Smith Company, York, Pa., had been taken over by the Bethlehem Steel Corporation. We are informed that this report is incorrect, there being absolutely no foundation for it.

PERSONAL.

R. H. SPERLING, formerly general manager of the British Columbia Electric Railway Company, has been granted a commission in the British navy.

G. GORDON GALE, formerly general manager and chief engineer, Hull Electric Company, has been appointed vice-president and general manager.

EDWIN H. VERNER has been appointed municipal engineer for Langley, B.C. He formerly held a similar position for Port Coquitlam and Coquitlam Municipality.

F. E. FIELD, M.Can.Soc.C.E., the engineer who has represented the city during the construction of the Montreal filtration plant, has been appointed superintending engineer in anticipation of the early operation of the plant.

J. M. WOODMAN, formerly superintendent of the C.P.R. terminals at Winnipeg, has been transferred to Montreal. R. C. MORGAN, formerly divisional superintendent at Fort William, will succeed him, and A. F. HAWKINS, of Moose Jaw, will go to Fort William.

OBITUARY.

RICHARD BELL, for the last twenty-three years chief engineer of the Sarnia, Ont., pumping station, died on February 19th from injuries received on January 23rd at the George Street station. Mr. Bell was 43 years of age.

PATRICK TALBOT BOWLER, who for almost a quarter of a century was city electrician of New Westminster, B.C., died recently following an operation. He had been in failing health for several years and resigned his duties early in 1916.

ASSOCIATION OF ONTARIO LAND SURVEYORS.

At the twenty-fifth annual convention of the Association of Ontario Land Surveyors, held last week at the Engineers' Club, Toronto, the necessity of a more comprehensive plan of highway construction in Canada, in the interests of national prosperity, was pointed out by Vice-President James J. MacKay, of Hamilton, in a paper which he read on "Good Roads."

The proceedings were closed by a luncheon which was attended by veterans of the association, who had held certificates since before Confederation, after which many of the members availed themselves of an offer to inspect some munition factories.

Officers elected are: President, James J. MacKay, Hamilton; vice-president, H. J. Beattie, Pembroke; secretary-treasurer, L. V. Rorke, Toronto.

The first central station in Japan was opened in 1887 with a 75-lamp dynamo supplying Tokio. The Lake Inawashiro plant has now six 10,000 horse-power turbines and transmits power 140 miles to Tokio at 115,000 volts. At the end of 1914 there were 1,940 stations generating electricity, 390 being central stations, 24 railway plants, 47 combined railway and central station plants, 1,366 isolated plants, and the remainder official plants. Water power is used in 695, steam in 788, and gas in 457 of the stations. The total capacity in 1914 was 608,554 kilowatts, of which 341,809 kilowatts was in central station plants, and 140,022 kilowatts in isolated plants. Water-power equipment totalled 366,243 kilowatts; steam 217,967 kilowatts; and gas 24,344 kilowatts. There were 21,909 miles of aerial, and 751 miles of underground transmission lines.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

PNEUMATIC CAISSON WORK ON THE PETITCODIAC RIVER BRIDGE PIERS*

DESCRIPTION OF AN UNUSUAL PIECE OF FOUNDATION WORK—VELOCITY OF RIVER, RAPID RISE OF TIDE MADE CONSTRUCTION DIFFICULT—METHODS OF CONSTRUCTION

By E. M. ARCHIBALD, A.M.Can.Soc.C.E.

(Concluded from March 1st issue.)

OWING to the first attempt at launching having proved unsuccessful, the second launching was thrown forward into a period of the highest spring tides, when the velocity of current was greatest. However, since the current at the location of No. 1 pier from our observations had never shown as much velocity as at No. 2 pier, on which all the calculations were based, it was decided to proceed with the placing of the caisson. The first tide having been passed through without any trouble developing, it was thought all danger was past. On the second ebb tide, however, after the heaviest run had appeared to be over, a species of tidal wave occurred which was deflected straight across the river when it reached the old piers and caught the caisson broadside on with a heavy surge, parted the breast lines, then snapped the heavy mooring cables like pipe stems. The men on the caisson pumped for their lives to the scow moored alongside, then to the boats, and followed the wreck downstream.

Caisson Design.—In view of the fact that the probabilities were that the bearing under the cutting edge would be very uneven and that the caissons would be subjected to very severe conditions, it was decided to make the design very rigid—much more rigid than the known stresses would warrant. That this decision was prudent, it may be mentioned that the one caisson which went adrift and was tossed around on the mud flats was in perfect condition when finally placed in position. The only damage was the breaking of the 12-in. x 12-in. cross-struts inside the air chamber. These were readily renewed after air had been applied.

Starting from the bottom of the caisson, we first find a 9-in. x 5/8-in. flat plate bolted to the lower timbers and forming a shoe for the cutting edge, which was formed out of an 8-in. x 16-in. hardwood timber bevelled off on the inside. On this were laid the 12-in. x 12-in. hard pine timbers, forming the outer wall of the air chamber. The inner wall consisted of 12-in. x 12-in. vertical timbers, securely screw and drift bolted to the outer timbers with 1-inch iron in all cases and large plate washers under both head and nut. Every fourth vertical timber passed up through the roof and continued well up to low-water elevation on the inside of the cofferdam, as we shall call the portion of the caisson above the roof of the air chamber. By means of 1-inch screw bolts, every 2 feet into the outer walls, this upright timber increased the rigidity and further prevented the tendency of the various timbers to pull apart under displacement when the cofferdam was pumped out.

The roof of the air chamber consisted of two tiers of 12-in. x 12-in. hard pine timbers placed transversely and with staggered joints. Great care was observed in securing tight joints everywhere, but more especially where the verticals passed through this roof, since there was the greatest danger of air leakage when under pressure. Heavy single-ply roofing paper was laid between the two tiers of the roof and all joints well pitched as a further precaution against leakage. Each roof timber was side-bolted to its neighbor with three 1-inch drift bolts.

Eighteen inches of 1:2:4 concrete reinforced with 1-inch rods spaced 12 inches apart, both longitudinally and transversely, was poured on top of the timber roof for additional strength and incidentally to further prevent air leakage. Another very important feature of this concrete roof was the purpose of keeping the centre of gravity as low as possible, resulting in greater stability while afloat.

The weak point in a caisson is the junction of the air chamber with the cofferdam above the roof. We consider the method adopted strengthened our work very materially. This consists, as shown by a reference to the plan, in a 12-in. x 12-in. waling timber immediately under the roof and another on top of the concrete roof, bolted every 2 feet in each direction.

Six 12-in. x 12-in. hard pine struts were placed inside the working chamber as close to the cutting edge as feasible to resist the inward pressure and six 1½-inch rods used to resist any possible outward pressure. In ordinary cases these rods are of doubtful value, but may have been of some benefit in the case of the caisson which went adrift.

Heavy roofing paper was placed between the two tiers of timber in the side walls of the air chamber as well as in the roof to prevent air leakage.

The air chamber was sheathed inside and outside and on the bottom of the roof with 3-inch planed hardwood sheathing with caulked joints.

Two threads of oakum were driven in all joints in the air chamber and well pitched.

All horizontal timbers were drift-bolted with 1-inch drift bolts, 22 inches long, every four feet.

The cofferdam consisted of a single wall of 12-in. x 12-in. timber, hard pine or white birch, half dove-tailed at corners, and drift-bolted every four feet. Six sets of 12-in. x 12-in. timbers served as transverse ties for the outer walls, the ends being dove-tailed in, and one set of longitudinals served the same purpose. At intersections, these ties were screw-bolted together.

*Paper read before the Canadian Society of Civil Engineers, February 22nd, 1917.

The cofferdam was divided into three compartments for convenience in pumping, as previously explained. Both below and above these bulkheads the concrete was poured in a monolithic mass.

The walls of each compartment were pierced with four 4-inch holes through which was passed a 4-inch pipe with an elbow and a 7-foot length of pipe on the inside of the caisson, forming a swinging joint to control the inlet of water for slowly flooding the caisson after concreting, when each tide's work was completed. This stopped the green concrete from scouring when the incoming tide boiled over the top of the cofferdam.

The air chamber roof was pierced with three 36-inch shafts, one being a man-shaft located in the centre of the caisson, the other two for material, one at each end and spaced to handle material with a minimum of handling.

Air was supplied through two 4-inch pipes located at opposite ends of the caisson. Two more 4-inch pipes through the roof were used as blow pipes for blowing water and sand from the air chamber.

A 1-inch whistle pipe was used at each material shaft for signalling purposes.

Two 1¼-inch pipes were installed for supplying fresh water to the air chamber, but were not used for this purpose. They, however, served for supplying compressed air for pneumatic drills used in drilling boulders.

Electric lights were used on removable leads run through the man-shaft, but were removed at the end of each low-tide shift.

Launching.—Both caissons were launched sideways about three-quarters of an hour before high water. Four 12-in. x 12-in. launchways were used, set at a slope of one in ten. Had the slope of the beach warranted it, a lesser slope would have been better. Four 12-in. x 12-in. runningways were placed under the caisson resting on the launchway—each runningway had a 6-in. x 12-in. board bolted on for a guide. All four runningways were roped fast to the launchway at the shore side of the caisson and ropes cut simultaneously when ready to launch. In order to check one end going faster than the other, timber dogs were used with one end made fast to the runningway and the other ready to drive into the launchway, should one end of the caisson start before the other. In addition, a four-part rope tackle was used at each end with the end passing around a snubbing post. With these preventatives and a crew trained to work together, there appeared to be no difficulty in getting the caisson started properly, but after taking water and before becoming waterborne, the caisson in two cases gradually swung off the ways up river in the direction of the river current, indicating that the slight current exerted enough pressure to make the launching a failure. Had launching been attempted at high tide, there seems no reason to doubt its success, but as there is only about twenty minutes of still water, no time would have remained to tow and moor. In one case the caisson, after dropping off the runningways, became waterborne a sufficient time before high-water to tow it across to place and secure the moorings, but in the other case it was necessary to wait a few days for a high tide enough to float.

Tallow was used on the launchways as a lubricant.

The outer ends of the runningways were weighted with rails to clear them from the caisson when afloat.

Towing.—A 35-ton dinkey used in switching operations, was used to tow the caisson to position. A 1⅛-inch steel cable, 1,600 feet long, was stretched across the river previous to launching, passing through a heavy snatch block on a scow, which carried the permanent moorings; the slack of the cable was kept off the bottom of the river by passing over another scow. After launching, the cable was attached to the caisson and the dinkey started towing until the caisson was brought into position alongside the mooring scow, where the moorings were quickly transferred from the scow to the caisson.

Moorings.—The formula used in calculating the moorings was:

$$P = W K \frac{V^2}{2g}$$

W = weight of water per cubic foot — 65.
K = constant (1.47 for square-ended caisson).
V = current in miles per hour.
P = pressure in pounds per square foot on exposed surface normal to current.

Current records taken with a ship's log showed a velocity of 9 knots per hour at spring tides and 6 knots per hour on neaps. These calculations showed a maximum strain of 26 tons had to be taken care of in moorings and two 1⅛-inch wire cables were used up river, one attached to a rock-filled crib in the river and the other to a "dead man" on shore. The downstream mooring was a single 1⅛-inch wire cable from a rock-filled crib in the river and a second 1⅛-inch cable fastened around the old pier adjacent to the final position for the caisson. A socket was attached to the end of each cable and to this a five-part tackle of ¾-inch wire cable was hitched, running through 14-inch diamond blocks, the free end passing around one of the cross-timbers inside the caisson, where it could readily be payed out.

All upstream moorings were carried to a bridle fastened in the end of the caisson. The bridle consisted of four 1⅛-inch wire cables fastened at one end through 1½-inch eye bolts into the caisson and all hitched together to a common shackle at the other end.

In addition to up and downstream moorings, four breast lines were used at each corner of the caisson, consisting of four parts of 4-inch circumference rope through double blocks for adjusting the position sideways.

A framework was built out from the old wooden pier on the line of the new pier, to which the caisson was breasted hard and used as a guide in sinking.

Sinking.—An endeavor was made to level the pier sites by blasting out high spots and filling low spots with small stone but was not attended with any great degree of success, on account of the scouring action of the current. Soundings taken at No. 1 pier showed hard and soft spots alternately and when the caisson was finally sunk, it was out of level as much as three feet and bearing very unevenly. A diver was sent down to try and obtain a more even bearing under the caisson, but very little success attended these efforts. Meanwhile, pumping out and concreting was proceeded with until sufficient weight had been put on to keep the caisson from floating when under enough air pressure to enable the "sand hogs" to go to work levelling up. The locks were installed and eight pounds of air pressure put on at low tide, driving out the water from the air chamber and enabling the men to start work. The entire upper end of the caisson was found open to the action of the tide, the opening being as much as three feet. After finally getting the caisson on a fairly even keel, concreting the top was proceeded with until the right elevation was reached to correspond with the diamond drill borings. Two courses of granite were added, after which old car wheels were used for

additional ballast. These were used instead of blocks of granite, which were to be used in erecting the shaft of the pier, on account of their greater specific gravity, reducing the top heaviness of the caisson. Even at that, it was necessary to pile up car wheels to a height of over twelve feet and to indicate how little excess weight there was, may be mentioned the fact that it was necessary to reduce the air pressure eight to ten pounds, even after the cutting edge was cleared, before the caisson would sink. Skin friction was found to run somewhat over 500 lbs. per square foot, the nature of the strata being largely fine sand.

As a precaution against overturning, two 1⅛-inch wire cables were used as a strap around the caisson to the old pier.

It is in order to state that the air work was only carried on at low-tide periods. Air was turned on while the tide had still 6 ft. to fall and the men were called out on the arrival of the bore, permitting six hours work each tide.

This decision as to low-tide work was due to the narrowness of the caisson compared to its height, No. 1 caisson being only 18 ft. wide and the height from the natural ground surface of the river bottom to high water was 50 ft.—the distance from ledge rock as found at No. 1 to high water was 77 ft. Car-wheel ballast to withstand the air pressure for working at any stage of the tide would have reached well above high-tide mark and made the caisson very top heavy and in great danger of overturning in the heavy broad-side current which prevailed at No. 1.

No difficulty was experienced in quickly blowing the water out of the air chamber with air pressure, until a heavy strata of clay was reached, which effectively sealed it, after which it was necessary to use the blow pipes to remove the water.

One of the many difficulties encountered and which caused serious delay, was the entrance of quick-sand into the air chamber on spring tides. This sand carried up on the flood tide, filtered through as much as 20 ft. of cover before getting under the cutting edge and would often fill the air chamber to within 18 inches of the roof. No means was ever found of wholly getting rid of this trouble—it would gradually disappear after the high spring tides were over, but since these high tides reappear at both full and new moon periods, it can readily be understood what a discouraging feature it was.

The average rate per day of sinking No. 1 and No. 2 caissons was 6 and 4.7 inches respectively. A progress diagram is shown in Plate 5 as well as the material passed through.

The slow progress made in sinking No. 2 was accounted for by the fact that the material was boulders of all sizes embedded in sand and clay. It was necessary to shoot these boulders constantly to clear them from beneath the cutting edge and to cut them down small enough to pass through the locks.

No serious difficulties were encountered in sealing the air chambers.

There were no fatalities in this caisson work and, in fact, throughout the entire work—a rather remarkable showing on a dangerous river. There were several cases of "bends" in which it was necessary to resort to the hospital lock.

The air supply was ample for the work, although on a few occasions both machines were operating at capacity.

After the sealing up of the caisson on solid rock, the car-wheel ballast was removed, the top of the concrete cleaned off, levelled up to an uniform bearing at elevation 39.25 and the granite shaft started. Pumping operations were, of course, necessary each tide, since the granite footing course was two feet nine inches below dead low tide, and progress was slow. Only a small section could be attempted each tide on account of the short time available and the enormous amount of cleaning. Plate 6 shows a plan of the granite pier. Granite was laid in each section and hearted up with 1:3:6 concrete. There was 315 cubic yards of granite facing and 300 cubic yards of concrete hearting to each shaft. For protecting the green concrete against scour, wooden shutters were used in sections, secured with rods down the side of the granite shaft to the timber caisson. The heavy current was very severe on these shutters, frequently up-ending them and breaking them in pieces wherever the slightest opening appeared, allowing the tide to get under them. This scheme, however, was the most successful for preventing scour of any used.

The above piers were built for the New Brunswick Government, Mr. A. R. Wetmore, provincial engineer, Mr. R. A. Malloy, assistant engineer on the work.

The contractors were Engineers & Contractors, Limited; Mr. E. R. Reid, president, and the writer chief engineer.

SPECIAL MEETING OF ENGINEERS' CLUB, TORONTO, TO CONSIDER NEW QUARTERS.

A special meeting of the Engineers' Club, Toronto, was held last Thursday, March 1st. This meeting was called to consider the question of new club quarters.

At the time the president, Mr. E. L. Cousins, called the meeting to order there was not a vacant seat in the lecture room. After some preliminary remarks in which the president referred to the history of the club, he called upon Mr. C. H. Heys, chairman of the house committee, to give the members some facts as to the estimated receipts and expenditures which might reasonably be expected in the event of a change of quarters being made.

Following Mr. C. H. Heys, Mr. M. P. White, on behalf of the new quarters committee, outlined the steps that had been taken by that committee in its effort to arrive at some definite proposal. Two were laid before the meeting, one providing for the remodelling of the present quarters by which the floor space would be practically doubled. The other proposal was for the club to occupy the 5th, 6th and 7th floors of the World Building on Richmond Street West. This would give the club a floor area of 15,000 square feet. The discussion was quite general, the consensus of opinion being that the World Building plan was the more desirable. When the vote was taken it was found it was practically unanimous in favor of moving to the World Building, there being only one dissenting vote. At the same time, it was felt that out of courtesy to the members of the club who were not present, a letter ballot should be taken before any definite move was made. The directorate was therefore authorized to send out a letter giving as much information as was thought necessary regarding the two proposals and thus secure an intelligent expression of opinion of all resident and non-resident members. This will be done within the next few days.

The number of companies incorporated under the Companies Act in Canada during the fiscal year ended March 31st, 1916, was 534, with a total capitalization of $157,342,800.

THE NECESSITY FOR ADEQUATE METHODS OF WATERPROOFING IN ROAD CONSTRUCTION.*

By C. J. Morrison.

A WHEEL and a road may be considered as two elements of a machine and the ideal requisites for each determined to be: (1) Perfectly hard and perfectly round wheel; (2) perfectly hard and level road.

The ideal road cannot be maintained but can be approached by constructing a moderately hard road which resists wear and disintegration.

In order to fulfil their requirements, roads must be waterproof, so as to protect them from the flowing, undermining, and penetration of water. Principles of waterproofing are simple, but are neglected.

Roads are constructed under five general conditions: (1) On level ground; (2) on inclined ground; (3) in cuts; (4) on embankments; (5) on side of slopes.

Each condition requires a different method of waterproofing and waterproofing is dependent upon: (1) Location of drains; (2) construction of road; (3) treatment of surface.

Comparative costs of construction and maintenance show that at the end of five years the total cost of a non-waterproof road and a semi-waterproof road are about

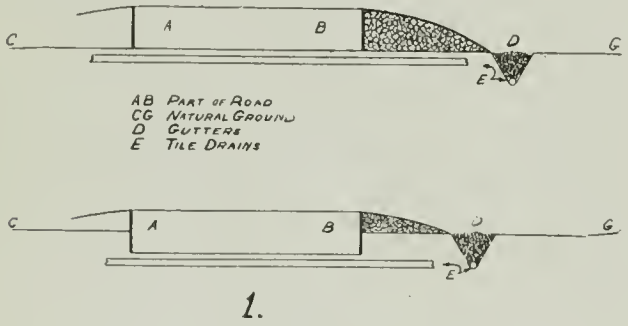


Fig. 1.—Construction on Level Ground.

equal, but that the former is practically useless while the latter shows little deterioration. Similar comparisons for waterproof roads are not yet available.

The ideal condition of things is obviously that in which a perfectly hard and perfectly circular wheel runs on a perfectly hard and level road. It might be said, therefore, that a steel wheel and a steel road would be suitable as in the case of railway practice. As a matter of fact, quite apart from the practical question of the cost of such a road, there are questions of adhesion, in the matter of gradients as well as storing, that a really hard road cannot be obtained. It may be at once said that if a moderately hard road could be kept level and entirely free from all unevenness of surface there could be nothing better than a truly circular metal wheel, and such a wheel being cheap and durable would doubtless be universally employed.

Ideal Road Impossible.—However, a thing so desirable as a truly level surface is exactly what it is impossible to maintain, and it is in order to mitigate the shocks caused by the tendency to deflect a vehicle from its movement in a straight course that yielding material such as solid rubber or pneumatic tires are employed on the periphery of a wheel. This soft material cannot be used without paying the penalty, not merely of wearing the wheel, but of wearing the road itself, and as a matter of fact, inasmuch as the contact between the wheel and the road departs from a point in the side elevation, or a line looked at in plan, by so much is wear between the surfaces in contact introduced.

Fig. 2.—Plainfield Road.

Conditions Beneath Surface.—In the next place, consider what goes on beneath the surface. If the road is not hard, then a certain amount of deformation must take place.

The injury done by this deformation will depend on two things: (1) The depth to which it extends; (2) the extent of permanent disintegration of the internal substance of the road.

Practical Requirements.—It is therefore obvious that, both as far as the surface is concerned and also the body of the road, what is required is a hard, strong substance which presents great resistance to wear, deformation and disintegration. If it is impossible, on account of expense, to make the whole of a road of such material, then the surface of the road should be of such material, and the

Fig. 3.—Break in Plainfield Road.

body of the road should be bound or cemented together with such material.

Necessity for Waterproofing.—In any case, as the road is exposed to the action of the weather, one of the very first conditions of its efficiency is that it must be waterproof, and that the surface must be sufficiently hard to prevent the formation of mud in wet weather and dust in dry weather.

*Abstract of paper read before the American Association for the Advancement of Science.

Definition of Waterproofing.—The term "waterproof" is used here in the broad sense, meaning both the protection of the road from water, and the rendering of the road itself impervious to water.

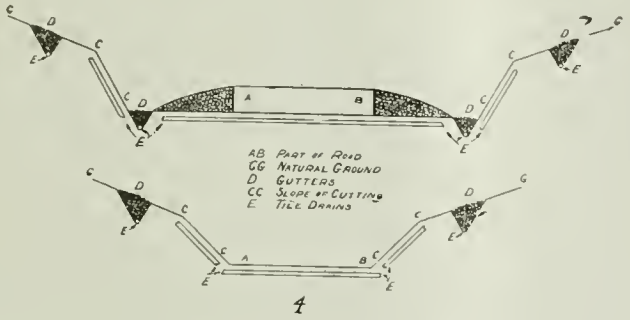


Fig. 4.—Construction in Cut.

Neglect of Waterproofing.—Roads must be waterproofed so as to prevent damage from abrasion, from undermining, from foreign substances being washed onto them, and from water penetrating the mass of the road. Although water is one of the worst enemies of the roads, the fact seems to have been given little attention and as a result, the cost of maintenance has increased enormously. Possibly the condition is due chiefly to the deplorable fact that road building has been largely in the hands of politicians and contractors instead of engineers.

Last winter hundreds of miles of roads were ruined because they were not waterproof. Water penetrated the body of the roads and froze. The result was upheavals and disintegration. Even the most elementary principles of waterproofing have been neglected, as will be illustrated later by photographs of various points on recently constructed highways.

Conditions Met in Construction.—As the elementary principles of waterproofing have been so completely neglected, it may not be amiss to describe them. Roads

Fig. 5.—Road in Cut Near Englewood, N.J.

are built under five general conditions and combinations of these conditions. The general conditions are: (1) On level ground; (2) on inclined ground; (3) in cuts; (4) on embankments; (5) on the side of slopes.

Roads on Level Ground.—A road built on level ground can be very easily waterproofed by building it slightly above the general elevation, by giving it a crown sufficient to cause any water to flow, by providing ample gutters on each side, by laying sufficient underdrains, and by applying a surface which is impervious to water. This method of construction is shown in Fig. 1. At frequent intervals, trenches or drains should be provided to carry off the water from the gutters.

Although it is so simple and inexpensive to properly waterproof a road built on level ground, the precaution is often neglected.

Sections of a new concrete road near Plainfield, N.J., are shown in Figs. 2 and 3. The body of this road is concrete and the surface is a soft asphalt. A far better road would have been secured by using a topping of integral waterproofed concrete instead of the asphalt. Although there has been no hot weather since this road was opened, the surface is already badly marked by horseshoes and wheels. These indentations will eventually go through to the concrete, water will collect in the depressions and percolate through the non-waterproofed concrete. Moreover, the road is neither properly protected from flowing water, nor adequately drained. We predict that it will not survive the second winter.

The shoulders on the sides of the road are a soft clay and the edges of the concrete have no protection. Already sections are being broken off, as can readily be seen in Fig. 6.

Roads in Cuts.—Roads built in cuts are probably the hardest to protect from flowing water, and there is therefore all the more necessity for a hard surface and integral waterproofing. Fig. 4 shows the general method of protecting a road in a cut and is so elementary that no comment seems necessary. Although so elementary, the

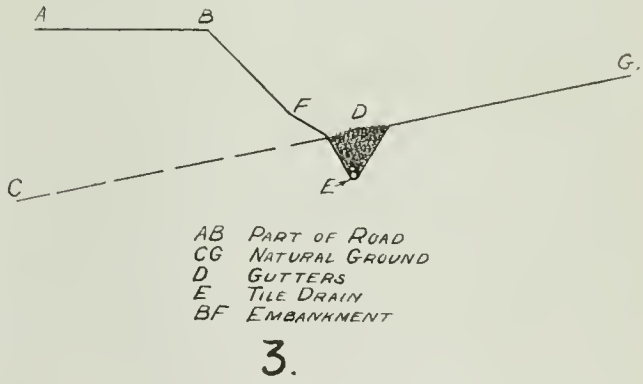


Fig. 6.—Construction on Embankment.

methods are quite generally neglected. A road in a cut at Great Notch, N.J., may be taken as an example. There is no waterproofing whatever and the net result is that the road has been rebuilt three times in three years. It will probably be rebuilt again next spring.

Fig. 5 shows a road in a slight cut near Englewood, N.J. Practically the same conditions prevail as at Great Notch. The picture shows ridges due to upheavals last February which had not yet been repaired on December 7th, when the photograph was taken. The present winter will probably about finish this road.

Roads on Embankments.—Roads on embankments seldom cause trouble if the most elementary principles are observed. These principles are shown in Fig. 6. The two salient features are to build the road so that it is integrally waterproof and so that the embankment is protected from flowing water.

Roads on Sides of Slopes.—Roads on the sides of slopes should be waterproofed in the same manner as roads in cuts with the exception that protection from flowing water is necessary only on one side.

REVIEW OF LAST YEAR'S DEVELOPMENTS ON NIAGARA AND OTHER POWER SITUATIONS.

IMPORTANT REFERENCE TO COAL PROBLEM.*

By Arthur V. White,
Consulting Engineer, Commission of Conservation, Canada.

WHILE reference will here be made to the Long Sault Rapids, St. Lawrence River; to the Chicago Drainage Canal; to the Lake of the Woods investigation, and to other water problems which, during the past year have been receiving attention from the Commission of Conservation, special attention will be devoted to a review of the power situation at Niagara Falls, because of the acute situation which has there arisen, and because, also, of its great national importance.

Long Sault Rapids, St. Lawrence River.—The charter of the Long Sault Development Co. has been declared to be unconstitutional. The company has been exerting strong efforts to secure a re-establishment of its status with respect to its former charter. The case was presented for argument before the Supreme Court of the United States during the past year.

The burden of the argument turned upon the question of jurisdiction. The main contention of the State of New York was that the Long Sault Development Company Act is unconstitutional. It has been so declared by the highest court of the state, and it was held that the decision of this court in a matter of this kind cannot tbe reviewed by the Supreme Court of the United States, being outside its jurisdiction. The state also contended that the charter was not a *contract*, as alleged by the company.

The decision of the court was rendered on December 11th, 1916. It states that the court had arrived at the conclusion that the Long Sault Development Company's "Act of 1907 was unconstitutional and void, and therefore it results that this case does not present any questions for decision under the Federal Constitution, and that, for want of jurisdiction, the writ of error must be *dismissed.*"

The Long Sault Development Co. wished to proceed with its construction of *dams and other works in the St. Lawrence River.* That this was the object the company had in view, in bringing its action, was clearly evidenced by the words of the counsel for the company, Mr. Henry W. Taft, who, before the Supreme Court, stated:

"Since the passage of the act the company has made, without success, diligent efforts to obtain the consent of congress, and, when the present embargo against the building of dams has been raised, will proceed again to obtain that consent."

Water Diversion by Sanitary District of Chicago.—The illegal diversion of water by the Sanitary of Chicago still continues.

The waters along the international boundary between Canada and the United States are a joint asset in which it has been regarded that each country is entitled to receive equal benefits. Nothing should be done in one country that would violate, or even prejudically affect, the interests of the other country. *Boundary waters should be kept within their own watersheds.*

In deciding against the Minnesota Canal Power Co.'s proposed division of the Birch Lake waters from the Lake of the Woods watershed to that of the Great Lakes, the courts of Minnesota have upheld this principle and rendered signal service to the conservation of boundary waters, by having them retained within their own watersheds.

Although Canada for some years has been suffering on account of the illegal diversion of the waters of the Great Lakes System through the Chicago Drainage Canal into the Mississippi River, yet it is hoped that the proceedings taken by the United States Federal Government in their courts, against the Sanitary District of Chicago, may yet result in restoring to the Great Lakes System the waters which Chicago, at present, is diverting in defiance of authority.

Lake of the Woods Investigation.—In January and February, 1916, the International Joint Commission held final public hearings relating to the Lake of the Woods investigation. These hearings were opened at International Falls by a committee of the commission, for the purpose of obtaining evidence respecting land values.

Immediately following adjournment, the hearings were continued at Winnipeg, before the full commission. These hearings at Winnipeg were called largely for the purpose of permitting those interested in power to make their representations. The data and conclusions presented by the consulting engineers in their preliminary report to the commission were considered, and the question of the relation of the regulation of the levels and outflow of the Lake of the Woods to power development was fully discussed by counsel and engineers representing the power interests.

In April, at Washington, D.C., the commission heard the final arguments of counsel representing the various interests affected by regulation of the Lake of the Woods. An executive meeting was held in September at Ogdensburg, N.Y., and at Ottawa in October.

There is now in preparation for transmission to their respective governments, a report by the commissioners respecting the regulation of the Lake of the Woods waters.

During the summer of 1916, extraordinary flood conditions prevailed on the watershed of the Lake of the Woods. For the six months from November, 1915, to April, 1916, the precipitation, on the whole Lake of the Woods watershed, exceeded that which fell during the same six-month period for the past 44 years,—for which records are available.

The flood conditions of 1916 strikingly emphasized the urgent need for an efficient, co-ordinated system of regulation and control of the waters of the Lake of the Woods watershed.

Niagara Power.—The coal problem, especially in the central portion of Canada, is a serious one. The two fuels which for power generation may be considered as competitors of water are petroleum and coal.

Petroleum, so far as large portions of industrial Canada are concerned, is out of the question. Respecting coal, the prices for this commodity are materially increasing year by year, and doubtless this upward movement will continue.

Representations are repeatedly being made by the United States authorities for the conservation of their own coal. Dr. George Otis Smith, director of the United States Geological Survey, in 1916, publicly stated:—

"Of the two fuels that can be considered as the competitors of water in power generation, petroleum has probably already passed its maximum of production, and the life of this source of power is to be measured by only a few decades. The coal resources of this country, on the other hand, are so

*Brief Abstract of Annual Statement to the Commission of Conservation, Canada, to be included in the Commission's forthcoming Annual Report.

large as to promise an abundance of fuel for scores of generations. Yet the price of steam coal shows a steady advance, offset, it is true, by increased efficiency in steam generation and utilization, but eventually the relative importance of water power the country over must increase.

"Already the great development of hydro-electric power in California in competition with oil and in Montana in competition with coal, forecasts the future relation of industry to this source of power. In these and adjoining states, irrigation and mining and transportation depend in larger measure each year upon hydro-electric energy, and it is because of this increasing contribution to the industrial life of the nation that public service and public utilities are more than names when applied to the utilization of water power.'

The United States is well aware of the economic importance of its coal reserves. Dr. Smith States:—

"Cheap power promises to be in some future century this country's largest asset in the industrial rivalry among nations. Our unsurpassed coal reserves reinforced by these water-power resources constitute a strong line of national defence in that they form the real basis for an industrial organization of the nation's workers. It is only through abundant and well-distributed power that the other material resources of the country can be put to their highest use and made to count most in the nation's development. The people's interest in water power is greatest in its promise of future social progress, and such an interest is well worth protecting."

Ten years ago, the Committee on Rivers and Harbors of the United States House of Representatives directed special attention to the industrial value of Niagara Falls, and the importance of this power supply when considered in connection with the supply of coal. It was urged that the chief and most important procedure for improving the power conditions were:—

First—The utilization of every American water power to its fullest extent.

Second—A more general location of manufacturers close to sources of fuel supply.

Third—The adoption of highly economical steam-driven power plants and more efficient methods of distributing and utilizing the energy.

In his statement to this committee, Mr. W. J. Clark said:—

"The enormous advantage which would accrue from the adoption of these last two suggestions will, however, be neutralized in a comparatively few years if some effort is not made to preserve the coal supply of America.

"It would be unfair to place the responsibility for the rapidly increasing use of coal in the United States, which threatens the ultimate exhaustion of the supply, entirely upon the manufacturing industries, for its consumption for transportation and other purposes has increased even more rapidly than for manufacturing uses. Attention should, however, be called to the leaps and bounds with which American coal production is increasing, so that the importance may be realized of preserving the supply by so far as is practical utilizing water power for all industrial purposes."

And again, it will be recalled that a few years ago the director of the United States Geological Survey, in referring to the world's coal supplies, stated:—

"This glance at the world's reserves of coal shows plainly not only that the United States leads all other countries in production, our annual output being nearly 40% of the total, but also that it possesses the greatest reserves. Yet in respect to no mineral is there greater need to emphasize the folly of exporting the raw material. Let us keep our coal at home, and with it manufacture whatever the world needs."

In November, 1916, during the coal shortage in the United States, in the course of the investigation into the alleged coal combine, held at Buffalo on November 28th, the district attorney in charge of the investigation put this question to one of the witnesses:—

"If the Canadians put an embargo on power when there is a power shortage, should we not put an embargo on their getting coal when there is a shortage here?"

Now, if citizens of Canada demand that electrical energy generated in Canada be used exclusively for citizens in Canada, and that its export to the United States be prohibited, then are not citizens of the United States equally justified in contending against the export of coal to Canada, because it is needed for citizens in their own country?

Good Working Basis is Practicable.—No country need be expected to send out of its borders that which is essential to its own existence.* Between the United States and Canada there is exchange of many natural and manufactured products, and no doubt the problems which are sure to arise in connection with such interchange—including the commodities of fuel and power—can be reduced to a good working basis.

Everyone familiar with the course of events which preceded the ratification of the Boundary Waters Treaty of 1910, knows that under the prior—but since lapsed—Burton Act, it was anticipated that some of the electrical energy developed in Canada would be exported to the United States. In fact, some people believed that it would not be possible to utilize in Canada more than a portion of the great amount of electrical energy that might be developed on her side of the boundary, and that consequently the United States market would import from Canada any surplus energy. These expectations have not materialized as was anticipated because the growth of industries dependent upon electrical energy has been so phenomenal in both countries.

Recollecting that the *doctrine of equal benefits* is basis to the Boundary Waters Treaty, each country should watch to see that no purely selfish interests shall operate to work any injustice to the other country. For example, after all factors have been duly weighed, if it is found that that any *bona fides* exist which require the exportation of an amount of electrical energy to the United States in order to enable that country to derive the beneficial use from its equity in boundary waters, such *bona fides* should be fully respected.

United States Fears that Canadian Markets May Absorb Electricity.—Those in the United States who have watched the increasing demand for electric power in their own country, have also observed that there has been an increasing demand for electric power in Canada. Those interested in power consumption in the United States have not hesitated to express the fear there entertained, that Canada on account of her growing manufactures and demands would rapidly absorb the electric energy which has been so much coveted for importation into the United States.†

The Secretary of War exercises jurisdiction over the Niagara River, and through the agency of the United States engineers, the War Department has kept in close touch with the Niagara situation. The restraint which this department has enforced upon the power companies, in order to keep them within treaty requirements, as well as within regulations of a domestic nature, is worthy of best commendation.

*For comments upon the application of this doctrine to the exportation of phosphate rock and other commodities, consult article by Arthur V. White, on the "Exportation of Electricity," which appeared in the "University Magazine," October, 1910; also, see "Toronto World" of 18th March, 1912; and "The Monetary Times" of 5th January, 1917. Consult, also, "Annual Reports" of Commission of Conservation, Canada.

†The author here quotes a number of views expressed by prominent United States citizens, confirming this statement.

Public Meetings in United States.—In August last, the War Department issued notice of public hearings to be held at Niagara Falls, N.Y., for the purpose of ascertaining what industries dependent upon power generated from the waters of the Niagara River at Niagara Falls, have been, or are likely to be adversely affected by a reduction of power obtained by them from that source. Blank forms for supplying information were also distributed to various companies. The report has not yet been made public.

The Water Power Investigating Committee appointed by the New York State Legislature, has held hearings at Niagara Falls, N.Y., and elsewhere and it is understood that this committee is about to issue a report.

The Hydro-Electric Association of Buffalo, N.Y., an organization seeking to carry out a plan for power distribution fashioned along the lines upon which the Hydro-Electric Power Commission of Ontario operates, has been urging before the Committee on Foreign Affairs their claim to the unappropriated 4,400 c.f.s.

United States Committee on Foreign Affairs.—At a meeting of the committee in July, it was addressed by prominent persons utilizing Niagara power, such as the managers, superintendents and consulting engineers of concerns like the Graphite Company, the Union Carbide Company and the chlorine industries. All speakers emphasized the fact that they were experiencing acute shortage of power. There were present about one hundred representatives.

Directing attention to the effects of the dye shortage, speakers emphasized that the United States was many times more dependent,—even though they did not know it,—upon products resulting from the use of Niagara power, than they ever were on the dye-producing industries of Germany. Speakers went on to demonstrate that it was utterly futile for the United States to devise and attempt to carry out any policy of war-preparedness, without at the same time augmenting the power available for the use of United States industries now located at Niagara. It was emphasized that this applies specially to plants manufacturing such products as chromium, utilized for the steel for battleships, and for high-speed cutting tools, which latter have so materially increased the output of metal-working establishments. There was also pointed out the need for increasing the output of the abrasive industries which supply carborundum and other products now so generally employed in the modern grinding processes which to a large extent have superseded, for many purposes, the work previously performed by lathes and other machine tools. Much attention was directed to the graphite products without the supply of which it would be simply impossible to produce the materials from which to manufacture many of the modern munitions of war.

Statements were made to show that the United States, in order to conserve and advance her industrial position in the world markets, could not afford to permit industries to locate in other countries where cheap power was being offered. Instances were mentioned, such as that of the Union Carbide Company locating in Norway and having available 100,000 h.p.; also a case in Canada where the American Cyanamid Co. had been forced to move out of the United States and locate in Canada at Niagara Falls in order to obtain a block of some 25,000 or 30,000 h.p. Such instances were cited in order to show that it would be extremely unfortunate to the upbuilding of the United States if industries had thus to expatriate themselves because the additional power necessary for their growth could only be obtained abroad.

After another meeting, in August, the committee announced that the hearings had furnished all information it required in order to proceed to "report out" the Cline Bill. Since the Presidential election, no further action has been taken.

In order to relieve the situation, the United States War Department has issued provisional and temporary permits, both to the Hydraulic Power Co. and to the Niagara Falls Power Co., to utilize during the winter months the full 4,400 c.f.s. remaining unappropriated under the Boundary Waters Treaty.

The Power Shortage in Canada.—All the power-producing resources of the Niagara power companies in Canada are taxed to their respective limits. There is no doubt that the use of electricity in Ontario has been greatly stimulated by reason of the activities of the Hydro-Electric Power Commission of Ontario. Rates have been lowered. The commission at present is directing the Niagara, Severn, Wasdell's Falls, St. Lawrence, Ottawa, Port Arthur, Eugenia, Muskoka, Northern Ontario, and Central Ontario systems.

It may be mentioned that during 1916 the Ontario Government purchased, for the sum of $8,350,000, the Central Ontario system. This comprised the entire holdings of the Electric Power Co., which embraced twenty-two subsidiary companies, including transmission lines of 285 miles at 44,000 volts.

In order to show the increasingly great demand for power in Canada, it may be stated that during 1916, *for industrial purposes, in the Niagara District alone*, the commission received *bona fide* applications for over 70,000 h.p. These applications came from companies like the American Dye & Chemical Co., Electro-Chemical Co., Canadian Carbide Co., Norton Emery Co., Carborundum Co., Riordan Pulp & Paper Co., Beaver Paper & Wood Co., etc. For the most part it has been simply impossible to supply such demands. The commission has exclusively furnished electric power to approximately 300 plants making munitions of war.

It may be commented that of the power which the Hydro-Electric Commission has been receiving from the Niagara companies, only about 10,000 h.p. has been derived from energy which was formerly exported. In other words, the additional supply of power from Canadian companies to the commission has been met by the installation of additional units.

This great demand for power in Canada will be met, chiefly, in two ways: First, the more immediate needs will be supplied from the existing power plants at Niagara on the Canadian side; second, by means of the proposed Chippewa development of the Hydro-Electric Power Commission, which is to provide about 200,000 h.p. under a head of 300 to 305 feet.

Canadian Power Plants at Niagara Falls.—The information respecting the three large power plants in Canada at Niagara Falls may briefly be summarized as follows:—

CANADIAN NIAGARA POWER COMPANY.

3 generators rated at 10,000 h.p. each ..... 30,000 h.p.
7 generators rated at 12,500 h.p. each ..... 87,500 h.p.

This makes a total rated capacity of 117,500 h.p. Space has been provided for an eleventh or spare unit. Up to November 1st, last, with eight machines installed having a rating capacity of 105,000 h.p., the company showed a maximum generation of approximately 93,000 horse-power.

ONTARIO POWER COMPANY.

3 generators rated at 10,000 h.p. each	30,000 h.p.
4 generators rated at 12,000 h.p. each	48,000 h.p.
7 generators rated at 13,000 h.p. each	91,000 h.p.
Total	169,000 h.p.

The hydraulic installation comprises two 18-ft. main conduits. A proposed third conduit has not been installed. The maximum total output has reached a little over 163,000 h.p.

ELECTRICAL DEVELOPMENT COMPANY.

4 generators rated at 10,500 h.p. each	42,000 h.p.
7 generators rated at 13,400 h.p. each	93,800 h.p.
Total	135,800 h.p.

It will be observed that the installation of the Electrical Development Co. exceeds its agreed 125,000 h.p., but it has been authoritatively stated that while the agreed quantity has been developed on peak load, it has not been exceeded.

With respect to the exportation of electrical energy from Canada to the United States, the Canadian licenses for a year ago provided for the following:—

	Approximate kilowatts.	Approximate horse-power.
Electrical Development Co. (Toronto Power Co.)	35,000	47,000
Ontario Power Co.	45,000	60,000
Canadian Niagara Power Co..	55,000	74,000
Total	135,000	181,000

The Canadian Government has had under consideration a proposal to reduce the export quantities to the following:—

	Horse-power.
Electrical Development Co.	16,000
Ontario Power Co.	60,000
Canadian Niagara Power Co.	40,000
Total	116,000

United States Power Plants at Niagara Falls.—On the United States side the Hydraulic Power Co. has remodelled its plant. It has two power houses jointly capable of developing about 158,000 h.p..

The Niagara Falls Power Co. has an installation capable of developing 100,000 h.p., but the amount of water apportioned this company by the War Department permitted only the development,—according to various combinations of units,—of from about 65,000 h.p. to 80,000 h.p.

These figures do not include power generated under the temporary winter licenses referred to above.

RAILWAYS IN CEYLON.

From the latest statistics it appears that the length of railway open for traffic in Ceylon at the close of September, 1915, was 692½ miles as against 672 miles at the corresponding period of 1914. The increase was due to the opening of a section of a line to Chilaw. In the course of 1914-15, rolling stock was increased by 18 new passenger and 86 new goods vehicles.

BEST PRACTICE IN CONCRETE ROAD CONSTRUCTION.*

By H. E. Breed.

IN design, the edge of the concrete slab next to the shoulder should be vertical and square cornered. Then if it becomes necessary to reinforce the shoulder with road metal a good joint can be made; and, more important still, if additional widening is required, it can be accomplished with a longitudinal joint of minimum size. We have very satisfactorily widened some miles of concrete roads built throughout the State (New York) in accordance with this design by adding four or more feet to one or both sides of the pavement.

Where the soil for the shoulders is unstable we are entrenching it with crushed stone or gravel four to six inches deep and 1½ to 3 feet wide. Although this gives good results, and makes for additional safety, still, if much traffic must be turned onto them the maintenance cost of these stone and gravel shoulders is so high as to justify the additional first cost of a wider pavement.

Accidents on 16-Foot Roads.—In order to obviate the danger of accidents on our 16-foot roads, we have been widening or mooning out the curves, so that in some cases for those of small radius at the centre the actual curve is as much as 22 to 24 feet wide. We have also considered it good practice to give the outside of these curves a super-elevation in order to make easier the steering of a car, to lessen the likelihood of skidding, and to insure greater safety in taking these curves at speed. This has been objected to as inducing people to travel round these curves at high speed, but speeding seems to be an inherent mania, unrelated to external conditions, and certain it is that banked curves lessen the casualties resulting from it.

Specifications.—Cracking of a concrete pavement is due generally to the unequal settlement of a poor subgrade. If the road is to be satisfactory it is of first importance that a good subgrade be secured. These we consider the essentials of a good subgrade:—

(1) It must have uniform bearing power. If an old road-bed is to be used it must be scarified, reshaped, and rerolled for the entire width of the pavement, removing all large stone to a depth of 6 inches.

(2) It must be dry. Ditches should be low enough to take away the water from under the pavement. With unstable soil good results can be secured by providing subdrains and spreading a layer of gravel—preferably run-of-bank gravel—over the subgrade to increase its stability. Material used for this purpose must be impervious; if it is porous it will act during wet periods as a reservoir, which, under conditions of frost, will break the pavement proper.

(3) It should have metal reinforcements (a) under very bad, i.e., unequal soil conditions; (b) wherever the supporting power of the subgrade changes; as from rock to earth, or passing over a trench.

Our experience indicates that the expense of reinforcement is not justified in gravelly or sandy soils where good natural drainage prevails.

The Mix.—The mix should be proportioned in such a manner as to give the greatest density. With our requirements for materials we have found that the proportions of 1 : 1½ : 3 most nearly do this. Our specifications

*Abstract of paper read before the American Road Builders' Association, Boston, Mass., February 8th, 1917.

provide that the concrete shall be mixed in the proportions of 1 volume of cement to 4½ volumes of sand and broken stone or gravel, and the proportions of fine and coarse aggregate are varied slightly as a result of field void tests so that the greatest density is obtained. Should the size or character of the materials change there would be a corresponding change in the proportioning of the mixture.

The coarse aggregate should consist of a well-mixed product of clean No. 1, No. 2 and No. 3 stone or gravel.

No. 1 size is that retained on ⅜-in. circular and passing a ⅝-in. circular screen.

No. 2 size is that retained on ⅝-in. circular and passing a 1½-in. circular screen.

No. 3 size is that retained on 1½-in. circular and passing a 2¾-in. circular screen.

It is provided, however, that not more than 25% of the total shall be No. 1 size, the proportions being so graded as to give a minimum of voids.

Aggregates should never be used unless they comply with the tests prescribed.

You may note that we allow, as our maximum size, stone that will pass a 2¾-in. ring, whereas most specifications permit only 1½-in. stone as a maximum. This may seem radical, but our reason for the increase in size is that we get equally as good if not better results from the larger stone, and at a cost decidedly lessened by our using more nearly the product of the crusher. Especially is the price to be considered on contracts where the local supply is crushed on the ground, as is the case in most of our work. If you desire economy, this change is worthy of your consideration. We save 15% in crushing costs by this use of stone larger than the previously accepted standards.

From a practical standpoint a pile of stone graded from ¾ to 2¾ ins. has more stability when properly mixed than stone graded from ¾ to 1½ ins. In our 1916 work we used stone up to 2¾ ins. in size; as an indication of the compressive strength per square inch of field cubes tested at an age of 26 days we have a grand average of 3,370 pounds per square inch for 504 cubes of stone and gravel, of which only 13¼% were under 3,000 pounds. Greater density can be obtained by using stone up to 2¾ ins. in size and with the larger size stone there is less probability of spalling at joints and along edges.

Sand.—Concrete pavement sand should be such that 100% should pass the ¼-in. screen; not more than 20% should pass a No. 50 sieve and not more than 6% should pass a No. 100 sieve. However, where more than 20% of the sand passes a No. 50 sieve, where it is well graded to give a low percentage of voids, and where it conforms to all other requisites, special permission for its use may be given by the chief engineer. Sand may be rejected if it contains more than 5% of loam or silt. All sand to be acceptable should have a compressive strength equal to Ottawa sand when tested in a proportion of one part cement to three parts sand at the same age, same consistency and using the same blend of cement as for Ottawa sand in the same proportions. It must be free from organic matter and any coating of grains.

Method of Mixing.—The concrete should be mixed in approved mechanical batch mixers. Mixing should be continued at a speed of not less than ten revolutions nor more than sixteen revolutions per minute, for at least one minute after all materials are in the drum and before any discharge is made.

If at any time during the progress of the work the temperature is so low that in the opinion of the engineer in charge of the work it will within 24 hours drop to 35° F. the water and aggregates should be heated and precautions taken to protect the work from freezing for at least ten days. Should these temperature conditions persist for two consecutive days, permission should be obtained from the chief engineer before proceeding. He will lay down such requirements of procedure as may be permitted; such procedure should be only for emergency work. In no case should concrete be deposited on frozen subgrade.

CANADIAN NORTHERN RAILWAY-HYDRO CONTROVERSY AT HAMILTON.

In connection with the controversy between the Ontario Hydro-Electric Commission and the Canadian Northern Railway regarding an entrance into the city of Hamilton, Ont., a committee of five representative citizens there has recommended that a broad and impartial investigation into the matter be carried on by a board of independent engineers. Until this report is submitted there is little likelihood of any definite action being taken by the city.

The engineers who compose this board are Col. R. W. Leonard, St. Catharines, Ont., formerly chairman National Transcontinental Railway Commission; Sir John Kennedy, Montreal Harbor Commissioner, ex-chief engineer, Great West Railway of Canada; Wm. F. Tye, consulting engineer, Montreal; Dr. Louis Herdt, electrical engineer, Montreal; W. J. Francis, consulting engineer, Montreal.

These gentlemen are all members of the Canadian Society of Civil Engineers. The local committee is urging delay until the board of engineers as above constituted has completed its investigation.

CANADA'S PRODUCTION OF MINERALS.

The tremendous expansion in Canada's production of minerals, particularly copper, iron, nickel, zinc and other ores needed in the manufacture of munitions, was interestingly dealt with by John McLeish, chief statistician of the Department of Mines at Ottawa, in an address to the members of the Royal Canadian Institute, Toronto, on the evening of January 27th. During 1916 the mineral output of the Dominion rose to 175,000,000 tons of ore, as compared with 135,000,000 in 1915, and the increase in production and in the market value of the minerals meant an extra $33,000,000 of money.

The pressing demand for certain metals had resulted in the development of ore bodies that had never been exploited before, owing to the cost of mining. An instance was the mining of molybdenum in Quebec, which last year produced ore worth $300,000. Chromite was another ore now being supplied from Quebec. Before the war the United States secured nearly its whole supply from New Caledonia.

Mr. McLeish stated that the lack of refineries in Ontario was unfortunate, but that they were now being built in a number of places in Canada. The refining of Canadian minerals at home would go on after the war was over.

There seems every prospect of rational coal mining being possible in Iceland, and preparatory work is being pushed ahead with considerable energy. For this purpose a Danish-Icelandish Coal Mining Company has been formed, with a capital of 350,000 kr., privately subscribed, which will be greatly increased when deemed necessary. A Swedish expert has examined and reported upon the Icelandish coal deposits; he estimates them to contain some 180,000,000 tons. The quality is said to be considerably better than hitherto supposed. The coal is reported to be fully equal to Scotch coal, and even if, on account of its large percentage of ash, it is unsuited for steamship boilers, a good market for it will be found for use for domestic purposes and power stations.

THE HYDRO-ELECTRIC POWER PLANT OF THE CEDARS RAPIDS MANUFACTURING AND POWER CO. AT CEDARS, P.Q.*

By J. C. Smith, M.Can.Soc.C.E.

THE development at Cedars Rapids is one of the most extensive which have been made in recent years in Canada, and the different phases of the work are in the first rank of importance in water power projects. The complete story of the work cannot be covered in a single paper, and it has been decided, therefore, to divide the subject into three sections, each being treated separately by the engineers connected with the development.

In the first of these sections Mr. Henry Holgate dealt with the history and legal phases of the organization, and the early stages of the work.

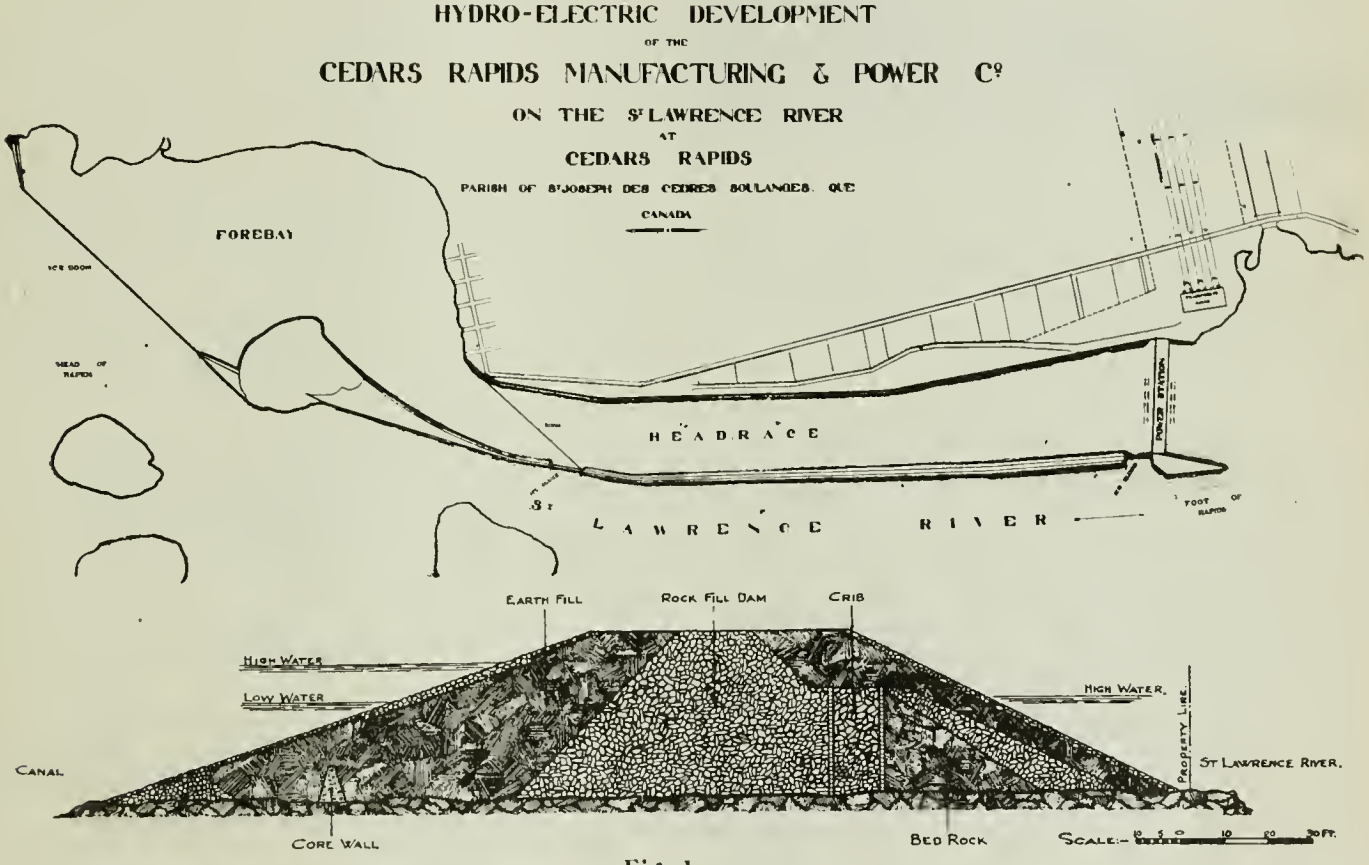


Fig. 1.

The third section will deal with the electrical equipment, installation tests, and the operation of the plant during the year 1915.

Embankment.—A general plan of the area covered by the works and a cross-section of the south bank are shown in Fig. 1. The south bank, extending the whole length of the canal, and separating it from the river, is the main feature of the construction.

The bank consists of rock-fill with clay bank or blanket on the canal side. At the end adjacent to the power house where the head against the bank is large, a concrete core wall extends down to solid rock, but at the upper end where the head is much less, this core wall was omitted and stripping down to rock was not deemed necessary.

Ice Protection.—The plan of the location of the forebay and canal shows that the general direction of the water entering the forebay above Isle aux Vaches is at right angles to the direction of the main stream. A small rapid exists just above Isle aux Vaches, and the velocity in the main stream is probably about 7 or 8 ft. per second, whereas the velocity across the section of the forebay into the canal is only about 2 ft. per second at full load. From the north bank and extending more or less at right angles to the current, a series of cribs has been constructed, with the idea of deflecting the water towards the main stream, thereby reducing the probability of floating material entering the canal.

In addition, two spillways have been provided in the south bank of the canal, one at the upper end, and one near the power house. The upper one consists of seventeen openings, each having a clear width of 15 ft. and closed normally by stop logs with the crest of the concrete sill about 10 ft. below lowest water level. The lower spillway is similar but not so large. The idea is that by adjusting the stop logs to give an overflow of about 2 ft., a high surface velocity can be obtained in the neighborhood of the spillway, so that ice guided by properly located booms will escape.

The power house, at present nearly 700 ft. long, will ultimately be about 1,200 ft. long, and in order to avoid the necessity of passing ice or other material clear across the full width of the power house to the spillway, openings have been provided at suitable intervals to facilitate the removal of such material.

In order to fill the gap between the present construction and the north shore line, a rock-fill crib dam resting

*Abstract of paper read before the Electrical Section of the Canadian Society of Civil Engineers.

on solid rock was constructed. This will act as a cofferdam when the power house is extended.

Equipment of Power House.—In the substructure, as constructed, provision was made for ten units, each of

Fig. 2.

about 10,800 h.p., and three exciters or auxiliary units, each of 1,500 h.p.

Before the design could be developed completely, the type of thrust bearing to be used in case the vertical unit was chosen, had to be decided upon. Three types are in common use., *viz.*, the oil pressure bearing, the roller bearing, and the Kingsbury bearing.

The oil pressure bearing consists of a stationary and a rotating plate, between which an oil film is maintained by means of pumps.

The Kingsbury bearing, like the oil pressure bearing, depends upon the maintenance of an oil film between a rotating and a fixed surface. The latter, however, is not a continuous plate, but a number of sectors each supported independently and free to rock slightly. By this device the oil is entrained between the fixed and rotating plates on account of its viscosity, and a film established as soon as the machine has made a part of a revolution. When full speed is reached, the rotating part rises about one or two-thousandths of an inch on the oil film, and the friction loss is then very small, being much less than in roller bearings.

A weak point in the Kingsbury bearing is that when coming to rest or starting up, the oil film is squeezed out, so that the machine starts practically metal to metal. By using a very hard babbit, containing a high percentage of tin, and a carefully machined and scraped surface, no injurious results take place, and with due precautions in starting and stopping the machines, the results obtained have been very satisfactory.

Having adopted the Kingsbury bearing, it was decided to place the bearing on top of the machine, so as to make it accessible and reduce the thickness of concrete required under the machine. If a thrust bearing of any type had been placed between the water wheel and the generator, a tunnel would have been necessary to give access to the bearings, and the floor level of the power house would have been changed.

In order to carry the thrust bearing on the generator, cast-iron brackets were designed by the water wheel company with special regard to rigidity as well as strength, the former being a most important consideration in view of the necessity of having as little vibration as possible, the oil film being, as stated, only from 0.001 to 0.002 inch thick. See Figs. 2 and 3.

Main Units.—It may be of interest to state why a vertical unit was adopted instead of a horizontal one.

Up to the time when the Cedars plant was designed, I had advocated the horizontal unit under almost all conditions, on account of various difficulties with thrust bearings, and the operating experience which many companies have had with vertical units. Nearly all difficulties are attributable to one of two causes: (1) Difficulties with thrust bearings; (2) difficulties with the generator.

The great advantage of the horizontal unit is that both water-wheel and generator are much more accessible, and that repairs on burnt-out coils of the generator can be made in much less time than in the vertical unit. In case of serious repairs being required, a vertical machine may have to be dismantled to make is sufficiently accessible.

It was deemed advisable to adopt a unit of such size that the total number required for the full development of 160,000 h.p. would not exceed eighteen. Each machine is of 10,000 h.p., giving a total of 160,000 h.p., and two spare machines.

The diameter of a single runner to develop this amount of power is 17 ft. 7 ins., and it is evident that a

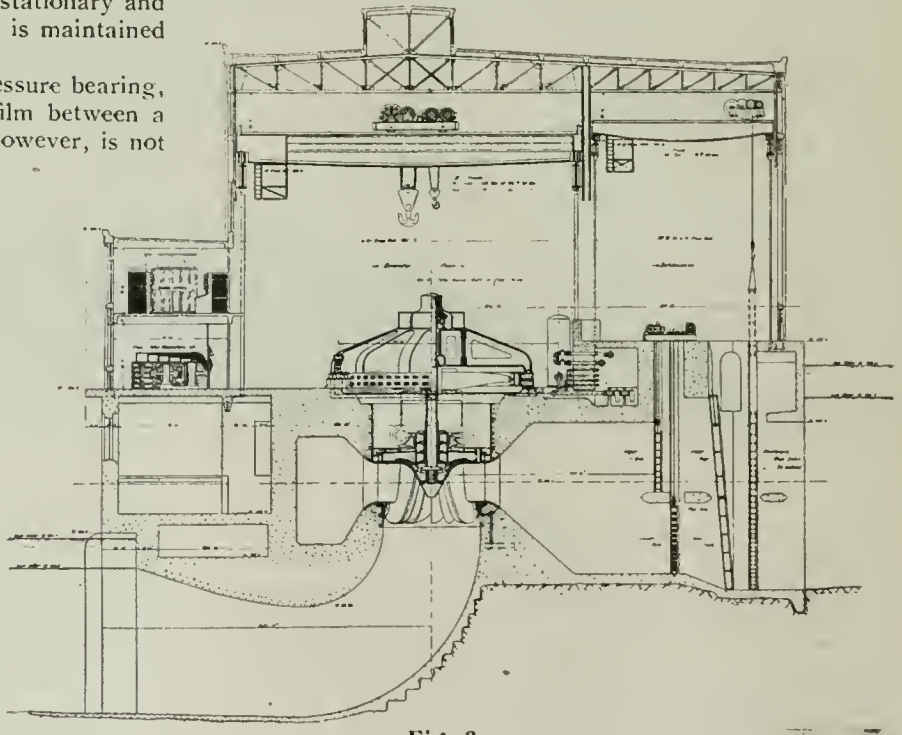


Fig. 3.

runner of such size cannot be used horizontally when the total head is only about 30 ft. The adoption of a horizontal unit involved the use of at least four runners of smaller diameter. These would run at a considerably higher speed than a single runner, and thus a relatively cheaper generator might be used with them than with the

single runner. On the other hand, a much larger amount of concrete would be necessary for the water wheel chamber to accommodate four runners, and as the shafts would probably be over 100 ft. long, difficulties would arise in operating them successfully. It also appeared difficult to make a satisfactory design which would admit the water evenly to all four runners. The water wheel efficiency was also an important consideration in this plant where the amount of water is fixed, and it seemed evident that the vertical single wheel would have about 5 per cent. higher efficiency than the horizontal wheel.

An exhaustive study of these alternatives and the results, were so much in favor of the vertical single runner that this type was adopted.

Description of Main Units.—Each main unit consists of a single runner vertical wheel, supported on a thrust bearing carried on top of the generator. The runner is 17 ft. 7 ins. diameter (the largest yet constructed) and develops 10,800 h.p. under 30 ft. head when making 55.6 revolutions per minute. The generator was designed with a view to minimizing the labor required in making repairs. The details of the thrust bearing were designed by Mr. Kingsbury, and a year's successful operation of the bearings has proved the correctness of his work.

The shaft is a solid forging with a coupling at the lower end where it is bolted to the water-wheel runner. It is held in line by two guide bearings, one a babbited bearing immediately below the thrust bearing, and the other a lignum vitæ water lubricated bearing just above the water-wheel. The length of the shaft from the top to the coupling is 32 ft., the diameter in the lower guide bearings is 25 ins., in the upper guide bearing 24 ins., and in the hub of the generator 27 ins.

To provide support, and to guide the water in the proper direction, a cast-iron speed ring was placed just outside the movable guide vanes controlling the amount of water admitted to the wheel, and in some respects the use of this speed ring is unique in this plant. The weight of the rotating parts is carried through the bridge on top of the generator and through the generator frame itself, to cast-iron pit liners, which transmit the load through the speed ring directly to the concrete foundations of the power house. The usual design provides an arch above the runner, which carries the load to piers on each side of the draft tube, instead of distributing it as above.

The control of the water is effected by the usual type of movable vanes. The cranks and links are situated in the wheel pit, above water, so as to be easily accessible, and are operated by two trunk piston engines connected to the rotating ring at points 180° apart.

The dimensions of all the main turbines are the same, and the total weight of the revolving system is 550,000 lbs. in each unit.

A special 300-ton jack was provided for dismantling the unit and for making the fine adjustments necessary in erection, the large cranes being unsuitable for such a purpose.

The jack can be arranged so as to lift the weight from the thrust bearing, and transmit it to the foundations through the cast-iron bridge over the generator as described above. By this means the deflection of this bridge is unaltered, and minute adjustments can be made in the mechanism of the thrust bearing, as the screw of the jack can be moved through any small amount desired.

By coupling the jack to the top of the shaft the weight can be raised so as to allow the thrust bearing to be removed. The weight can then be lowered about an inch until the rim of the generator rests on six blocks. After loosening the generator hub from the shaft, the water-wheel runner can be lowered about an inch more until it rests on a stationary base ring embedded in the concrete. The generator rotor can then be removed, the shaft can be disconnected from the runner, and the runner itself can be removed if necessary.

The arrangement proved of considerable use, particularly in view of the difficulty of making fine adjustments with the cranes.

Governor System.—The governor system was supplied by the I. P. Morris Company and operates by what is known as the open system.

The following regulation was guaranteed with the governors:—

Load change.	Speed change. Load off to zero load.	Speed change. Load on from zero load.
10%	2%	2%
25%	5%	5·25%
50%	11%	11·5%
100%	27%	30·5%

For supplying air to the governor accumulator tanks, two air compressors each delivering 50 cu. ft. of free air per minute were installed.

General Features and Design.—In the choice and arrangement of the auxiliary machinery facility of maintenance and operation were specially considered. All the auxiliary apparatus was therefore located on practically the same level as the main units, so as to be in sight of the men operating the main units. No machinery vital to the operation of the plant is located on lower levels or in tunnels.

FOURTH CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS—APRIL 10-14, 1917.

The prospects for the success of the Fourth Canadian and International Good Roads Congress, to be held under the auspices of the Dominion Good Roads Association in the Horticultural Building, Ottawa, from Tuesday, April 10th to 14th, inclusive, are very bright.

An interesting programme is being prepared and it is expected that papers and addresses by highway engineering experts will be presented, while road builders from all parts of Canada and the United States will be present and take part in the discussions. Profiting by the experience of the past, it is the intention to have the different lecturers and speakers simplify their deliverances as much as possible so that the layman can more readily understand what is meant.

As usual, there will be an exhibition of road machinery. Canadian and United States manufacturers of road machinery have announced their intention of placing on view a full line of their products.

The Dominion Good Roads Association, desirous of obtaining greater legal powers and of broadening its scope and increasing its usefulness, will present a bill before the adjourned session of parliament, asking for Dominion incorporation. The details of this bill, as well as the new constitution and by-laws, will be explained to the delegates, who will be asked to ratify the measures taken by the executive. The constitution will follow the general lines adopted by similar organizations in the United States, with such modifications as are suggested by local conditions.

DEFINITION OF TERMS USED IN SEWERAGE AND SEWAGE DISPOSAL PRACTICE.

THE Committee of Sewerage and Sewage Disposal of the Sanitary Engineering Section of the American Public Health Association at the last annual meeting of the association, submitted a report defining the terms used in sewerage and sewage disposal practice. The report was tentative and was submitted with the hope that it would bring out a full discussion of the subject. It is the purpose of the committee to amend these definitions in accordance with the weight which may be given in the discussions, with the view of establishing terms that may be generally acceptable to all engaged, or interested, in work of this character.

The suggested definitions follow:—

Sewage is the spent water supply containing the wastes from domestic, industrial or commercial use, including such surface and ground water as may enter the sewer.

Domestic sewage is that discharged from residences or institutions, and contains water-closet, laundry and kitchen wastes.

[1]Industrial wastes are the liquid wastes resulting from the processes employed in industrial establishments.

Street wash is the liquid flowing on and from the street surface.

Surface water is that portion of the precipitation which runs off over the surface of the ground.

Storm water is that portion of the precipitation which runs off over the surface of the ground during a storm and for such a short period following a storm as the flow exceeds the normal or ordinary run-off.

Ground water is that which is standing in, or passing through, the ground.

Drain is a conduit intended to carry storm, surface and ground water.

Sewer is a conduit for carrying sewage.

Common sewer is a sewer in which all abuttors have equal rights of entrance and use.

House connection is a pipe leading from a building to a common sewer.

Lateral sewer is a sewer which does not receive the sewage from any other common sewer.

[2]Submain or branch sewer is a sewer into which the sewage from two or more lateral sewers is discharged.

Main or trunk sewer is a sewer into which the sewage from two or more submain or branch sewers is discharged.

[3]Separate sewer is a sewer which is intended to receive only sewage and not storm or surface water.

Combined sewer is a sewer intended to receive both sewage and storm and surface water.

Intercepting sewer is a sewer generally laid transversely to the general sewer system to intercept all the sewage collected by the sewers of a separate system or the dry-weather flow of sewage, and such additional storm and surface water as may be determined, from a combined system.

Relief sewer is a sewer intended to carry a portion of the flow from a district already provided with sewers of insufficient capacity, and thus prevent overtaxing the latter.

Sewer system is the collecting system of sewers and appurtenances, together with such small pumping stations as may be required to lift the sewage from low-level districts.

Combined system is a system of combined sewers.

Separate system is a system of separate sewers.

Sewerage works comprise the sewer system, main pumping stations, treatment works, means of disposal of effluent and sludge, and all other works necessary to the complete collection, treatment and disposal of the sewage.

Manhole is a shaft, or chamber, leading from the surface of the ground to the sewer, large enough to enable a man to gain access to the latter.

Lamphole is a small vertical pipe or shaft leading from the surface of the ground to the sewer, for admitting a lantern or reflected light for purposes of inspection.

Wellhole or drop manhole is a vertical shaft in which sewage is allowed to fall from one sewer to another at a lower level.

Inlet is a direct connection between the surface of the ground and the sewer, for the admission of surface or storm water.

Catch basin is a chamber inserted in an inlet to prevent the admission of grit and other coarse material into the sewer.

Flush tank is a tank in which water or sewage is accumulated, to be quickly discharged later, for the purpose of flushing the sewer.

Regulator is a device for controlling the quantity of sewage admitted to an intercepting sewer.

Outlet is the end of a sewer or drain from which its contents are finally discharged.

Storm overflow is a weir or orifice for permitting the discharge from a combined sewer of that portion of the storm flow in excess of that which the sewer is intended to carry.

Sewage disposal is a generic term applied to the act of disposing of sewage matter by any method.

[4]Sewage treatment is the process to which sewage is subjected in order to partially remove its impurities and render it fit for final discharge.

Contamination is the introduction into a water of bacteria or other substances which tend to render it unsuitable for domestic use.

Pollution is the introduction into a water of substances of such character and in such quantity that they tend to render the body of water or river objectionable in appearance, or to cause it to give off objectionable odors.

Influent in sewage practice is a term which applies to sewage that flows into any sewage treatment device.

Effluent in sewage practice is a term which applies to sewage that flows out of any sewage treatment device.

Putrescibility is the capability of sewage, effluent, or wet sludge, to putrefy under the conditions to which it is subjected.

Stability is the capability of sewage or effluent to resist putrefaction under conditions to which it is subjected.

Relative stability is the ratio of available oxygen to the oxygen required to prevent putrefaction, expressed in per cent.

Clarification is the removal of the suspended and colloidal matters.

Suspended solids are the solids, both organic and inorganic, that are not held in solution in a sewage or effluent; these solids being quantitatively determined in the laboratory by retention on filter paper.

[1]In the opinion of the committee the term "Industrial Wastes" is preferable to "Trade Wastes."

[2]The committee is of the opinion that preference should be given to the term "Submain Sewer" rather than to "Branch Sewer."

[3]In the opinion of the committee the use of the term "Separate Sewer" is preferable to "Sanitary Sewer," which latter term should be discontinued.

[4]The term "Sewage Purification" should be abandoned.

Settling solids are those suspended matters which will subside in quiescent sewage in any specified length of time.

Colloidal matter is suspended matter which is so finely divided that it is no longer acted on by gravity, and remains suspended indefinitely, yet will not pass through a parchment membrane in the ordinary process of dialysis.

Screens.—A screen is a device containing openings of proper size to retain a part of the suspended matter of sewage.

Coarse screen is one having openings in excess of ½ in. in least dimension.

Fine screen is one having openings of ½ in., or less, in least dimension.

Bar screen is one composed of parallel bars or rods.

Mesh screen is one composed of a fabric, usually of wire.

Grating.—A grating consists of two sets of parallel bars in the same plans, the sets intersecting at right angles.

Perforated plate screen is one made of perforated plates.

Band screen is one consisting of an endless band or belt which passes over upper and lower rollers.

Wing screen is one having vanes, uniformly spaced, which rotate on a horizontal axis.

Drum screen is one in the form of a cylinder or cone, consisting of perforated plates or a wire mesh which rotates on a horizontal axis.

Disc screen consists of a rotating circular perforated disc, with or without a central truncated cone of similar material mounted on the centre.

Cage screen consists of a cage having three sides made of parallel bars or rods, so arranged that it may be lowered into the sewage, and raised therefrom for cleaning.

Tank treatment is the detention of sewage or sewage sludge in tanks, either quiescent or with continuous flow.

Grit chamber is a chamber or enlarged channel in which the cross-section of sewage flow is so designed that the velocity is such that only heavy solids, such as grit and sand, are deposited, while the lighter organic solids are carried forward in suspension.

Sedimentation tank is a tank for the removal of suspended matter either by quiescent settlement or by continuous flow at such a velocity and time of retention as to allow deposition of suspended matter.

Dortmund tank is a vertical sedimentation tank, usually cylindrical, in which the raw or partially treated sewage enters the lower part, flows upward and passes out near the top. The sludge is drawn before it becomes septic from the conical or hopper-shaped bottom.

Hydrolytic tank is a tank in which by biological processes a portion of the suspended matter is converted into liquid and gaseous form.

"Septic" tank is a horizontal, continuous-flow, one-story sedimentation tank through which sewage is allowed to flow slowly, to permit suspended matter to settle to the bottom, where it is retained until anaerobic decomposition is established, resulting in the changing of some of the suspended organic matter into liquid and gaseous substances and a consequent reduction in the quantity of sludge to be disposed of.

Travis tank is a 2-story tank consisting of an upper, or sedimentation, chamber, with steeply sloping bottom, terminating in one or more slots through which the solids may slide as deposited into the sewer or sludge digestion chamber, through which a predetermined portion of the sewage is allowed to pass for the purpose of seeding and maintaining bacterial life in the sludge and carrying away decomposition products, thus inducing digestion of the sludge attended by its reduction in volume.

Imhoff or Emscher tank is a 2-story tank consisting of an upper, or sedimentation, chamber, with steeply sloping bottom, terminating in one or more slots through which the solids may slide as deposited into the lower or sludge digestion chamber—these slots being trapped so as to prevent the rise of gas and solids from the lower chamber—the lower chamber being provided with vents for the escape of the gases, the tank being so constructed as to facilitate the passage of the sewage quickly through the upper chamber and prevent the flow of sewage through the digestion chamber, and so operated that the sludge may be thoroughly decomposed, rendered practically free from offensive odor and so filled with gas that it can be readily drawn off and dried.

Activated sludge process consists in the agitation of a mixture of sewage with about 15 per cent. or more of its volume of bacterially active liquid sludge in the presence of ample atmospheric oxygen for a sufficient period of time to at least coagulate a large proportion of the colloidal substances, followed by sedimentation adequate for the subsidence of the sludge flocculi; the activated sludge having been previously produced by aeration of successive portions of sewage and maintained in its active condition by adequate aeration by itself or in contact with sewage.

Chemical precipitation consists in adding to and thoroughly mixing with the sewage such chemicals as will, by reaction with each other or with the ingredients of the sewage, produce a flocculent precipitant and subsequent sedimentation.

Sludge is the suspended matter of the sewage deposited in tanks or intercepted at the surface of filters, mixed with more or less water.

Sludge digestion is the biological process by which organic matter in sludge is gasified, liquefied, mineralized or converted into stable organic matter.

Separate sludge digestion is the digestion of sludge in tanks entirely independent from the tanks in which it is produced.

Sludge drying bed is a natural or artificial layer of porous material upon which sludge is dried by drainage and evaporation.

Sludge concentration is the process of reducing the volume of sludge and increasing its proportion of solids by allowing it to stand in a suitable tank until the solids settle down and drawing off the relatively clean water at the top.

Sludge drying is the process of drying sludge by natural or artificial heat.

Sludge dewatering is the process of removing a portion of the water contained in the sludge by draining, pressing, centrifuging or by other natural or mechanical processes.

Sludge pressing is the process of dewatering by the exertion of pressure, the solids being retained by a cloth fabric which permits the water to pass through it.

Sludge cake is the mass of dewatered sludge resulting from sludge pressing.

Scum is a floating mass of sewage solids buoyed up in part by entrained gas or grease, forming a greasy mat which remains on the surface of the sewage.

Screenings constitute the material removed from sewage by screens.

Grit is the heavy mineral matter deposited from sewage.

Sleek is the oily film of microscopic thickness present on the surface of waters about and often extending a considerable distance from sewer outlets.

Sewage oxidation is the process whereby through the agency of bacteria, in the presence of air, the organic matter is converted to a more stable condition or into mineral matter.

Irrigation is the generic term applied to the process of sewage treatment in which the sewage is applied to land for the primary purpose of purifying the sewage and the secondary purposes of supplying water and fertilizer to crops.

Surface irrigation is the process in which sewage is applied to and distributed over the surface of cropped ground.

Subsurface irrigation is the process in which sewage is distributed beneath the surface of the ground by means of open-jointed pipes.

Sewage farm is an area of land on which crops are raised and to which sewage is applied on or beneath the surface of the soil and is absorbed by vegetation, evaporates or percolates to the ground water.

Intermittent filter is a natural or artificial bed of sand or other fine-grained material to which sewage is intermittently applied in doses, and which by its capillarity holds the sewage for a time sufficiently long, in the presence of air, to effect by biological processes a high degree of purification.

Contact bed is a water-tight basin filled with coarse material, such as broken stone, in contact with which the sewage is for a time held by control of the underdrains—the cycle of operation involving periods of filling, standing full, emptying and resting empty—so regulated as to secure such contact with the bacterial films adhering to the surface of the coarse material, and such aeration of the bacterial surfaces as may be required to oxidize the sewage.

Slate bed is a tank filled with slabs of slate or other similar material, laid horizontally and spaced an inch or more apart vertically, equipped so that it may be filled with sewage, allowed to stand full for a definite period of time, drained and allowed to stand empty for a time, for the purpose of oxidizing the organic matter deposited upon and adhering to the slates.

Trickling filter is an artificial bed of coarse material, such as crushed stone or clinkers, over which the sewage is distributed as a spray from fixed nozzles or as a film from moving distributors, through which it trickles to the underdrain system, coming in contact with the bacterial films adhering to the surface of the stones, and in which such aeration of the bacterial surfaces as may be required to oxidize the sewage is afforded.

Dosing apparatus is the apparatus used for regulating the application of sewage to filters or for applying the required quantity of chemicals to sewage.

Sprinkler nozzle is a nozzle used for applying sewage in the form of a spray to trickling filters.

Distributor is a movable pipe or channel which distributes sewage upon the surface of a trickling filter. There are two types of distributors—the rotary and the travelling; the rotary moves about a central axis with delivery to a circular filter; the travelling moves back and forth the length of a rectangular filter.

Dosing tank is a tank into which raw or partially treated sewage is introduced and held until the desired quantity has been accumulated, and then discharged at such a rate as is necessary for the distribution essential to the subsequent treatment.

Disinfection is the destruction by the agency of some chemical, of a large percentage of the bacteria in sewage or contaminated water, so as to reduce the danger of infection to a negligible quantity.

Sterilization is the destruction, by the agency of some chemical, of all the bacteria in sewage or contaminated water, including their spores.

Nuisance (in relation to a polluted stream) is a condition which is offensive to the sense of sight or smell.

A clean river in regard to sewage is one which gives no sensuous evidence of sewage pollution and from which a wholesome drinking water can be obtained by practicable methods of water purification.

PEAT AND ITS UTILIZATION.

By R. O. Wynne-Roberts.

IT is somewhat remarkable that whilst Canada has experienced considerable difficulty in obtaining coal from the United States, we have great deposits of peat waiting to be utilized. This anomalous situation is doubtless due to our intimate acquaintance with coal and to the absence of practical experience with peat. Peat is used as domestic fuel and for the generation of power on a large scale in Russia and in a smaller measure in Norway, Denmark, Germany, Italy, Ireland and other countries. As stated by Mr. B. F. Haanel, B.Sc., whose report on "Peat, Lignite and Coal," published in 1914, will be freely quoted, "The problem which confronts Canada is not conservation, but the best means of rendering available the various supplies of low-grade fuels. The great coal measures of Canada are situated in the extreme east and west; but, lying between these points is a vast territory devoid of coal measures, which is, at the present time, dependent on some foreign source for a fuel supply. In one sense conservation is being practised to a very high degree, because, in certain parts of the country, practically all the coal required for industrial and domestic purposes is being imported from the United States, while valuable fuel deposits are lying practically intact. But this kind of conservation never leads to commercial or industrial prosperity, and cannot, therefore, be recommended."

Many of the peat bogs, which are peculiarly adapted for manufacture into fuel for domestic and power purposes, are conveniently situated as regards transportation facilities and contiguous industrial communities.

The peat bogs which have been investigated in Ontario are estimated to produce, roughly, about 65 million tons, with 25 per cent. moisture; Quebec, about 40 million tons; Manitoba, about two million tons. The lignite beds of the Prairie Provinces, according to Mr. D. B. Dawling, are capable of yielding about 100 million tons for one thousand years, but at present the quantity mined is insignificant compared with the immense deposits that are available. The economic results of importing coal and exporting our money need not be discussed here, but it is evident that if our peat and lignite fuels were utilized in a scientific manner and on an adequate scale much anxiety, discomfort and loss due to the severity of the weather and the difficulty of obtaining imported coal would have been minimized.

Each class of fuel must, of course, be used in a particular manner if the best results are to be secured, and peat requires special attention, because in its natural condition it contains approximately 90 per cent. of water. When the bog is thoroughly drained the moisture content may be reduced to 88 per cent. Mixing with dry peat or hay and pressing, the percentage of water can be reduced to 70 to 75 per cent., two pressings to 53 per cent., and by subsequent drying to 25 or 30 per cent. The degree to which peat has been humified has a considerable effect on the facility of extracting the water. Peat of recent deposit is more fibrous than the older beds, and water can be pressed out readily, but when humification has been carried to great extent hydrocellulose or gelatinous substance is present, and this absorbs water and increases in bulk until it has the consistency of soft soap. Well-humified peat, which has been thoroughly pulped and repulped, has the appearance, when dry, of a high-class lignite. It has a very fine texture, is hard and dense, and offers considerable resistance to breaking. The separation of the water from the peat has occupied the attention of many, and the data that is available is interesting information to those who are associated with the question of sewage sludge disposal, because the difficulties encountered are much alike.

Owing to the fact that peat is a low-grade fuel, which must be manufactured and sold at a comparatively low cost if it is desired that it should serve as a substitute for coal, or even when it is used in gas producers, the process of excavation, pulping, drying, and so on, must be arranged in such a way that the cost of labor and power is kept as low as possible. If peat can be manufactured successfully in Russia, Germany, Norway and Denmark, where the climatic conditions are not so favorable as those obtaining in Canada, it is within reason to assume that an even greater degree of success could be realized in this country.

The most promising way of utilizing peat is by gasification in gas producers and the recovery of the nitrogen. The total quantity of gas having a calorific value of about 140 B.t.u. per cubic foot is estimated at 90,000 cubic feet per ton of 2,000 lbs. of absolutely dry peat, or, say, 67,500 cubic feet from peat containing 25 per cent. of moisture. If 12,000 B.t.u. are allowed per b.h.p. hour, each ton of moist peat will give approximately 787.5 b.h.p. hours, of which about 75 per cent. will be available for power, that is, 590 b.h.p. hours. As already stated, there are about 65,000,000 tons of peat in Ontario, and the potential power of this fuel if utilized in this manner will be, roughly, 4,570,000 brake horse-power years, which would furnish 45,700 horse-power for 350 days per year for 100 years, so that Ontario has a valuable source and asset which is waiting to be utilized. But this is not all. The average percentage of nitrogen content in the peat beds which have been investigated is about two—it ranges from 1.26 to 2.77 per cent. If the efficiency of ammonia recovery process is assumed to be 70 per cent., the quantity of sulphate of ammonia from 2 per cent. nitrogen content will be about 100 pounds per ton of peat containing 25 per cent. moisture; consequently, the Ontario peat bogs are capable of yielding, through the agency of recovery gas producers, about 6,500 million pounds, or 3.25 million tons, of sulphate of ammonia. Spreading this over 100 years equals 32,500 tons per annum. This sells at present at about $70 per ton, but we will suppose, for the purpose of arriving at a conservative estimate, $60 per ton. Furthermore, let the value of energy be placed at $12 per b.h.p. per annum. Ontario alone possesses a potential gross annual income of:—

Gas power, 45,700 h.p. at $12	$ 548,400
Sulphate ammonia, 32,500 tons at $60	1,950,000
	$2,498,400

It will, of course, be necessary to pay for the cost of producing the power and sulphate, but it is not pertinent to the object of this article, which is to show that Ontario has a valuable asset in the peat beds, and what applies to Ontario is applicable to the other provinces. Saskatchewan, Manitoba and Alberta have vast areas of lignite which can be utilized, and these also constitute a most valuable natural resource that awaits utilization.

The gas may be used for many purposes—for driving gas-engines, raising steam, industrial processes, domestic heating, etc. As Ontario has a comprehensive hydro-electric system, it is manifest that peat can be used for the development of power only where hydro-electricity is not available at equal cost, but the production of gas will, doubtless, be utilized for other purposes. With regard to ammonium sulphate, it may be stated that it is used in immense quantities as fertilizer, and the bulk of it is derived as a by-product of the destructive distillation of coal. Dr. Lunge, in his fifth edition of "Coal Tar and Ammonia," states that "Synthetical production of ammonia from atmospheric nitrogen must find its limits in the impossibility of producing the requisite enormous amount of electrical energy, whether by water-power or otherwise. The principle source of ammonia will be always the nitrogen of coal," which will include peat and lignite. In 1915 Canada imported $1,087,000 worth of fertilizers of different classes, and, as the soil is reduced in fertility, due to gradual exhaustion, more fertilizers will be necessary. Peat and lignite, therefore, afford excellent local sources for the supply of ammonium sulphate. The following table will show what results are obtained by the use of this class of fertilizer:—

Country.	Sulphate of Ammonia per Acre. Lbs.	Total Crops Raised per Acre. Wheat. Lbs.	Barley. Lbs.	Oats. Lbs.	Potatoes. Tons.
Belgium	17.83	2,228	1,908	2,572	6.58
Germany	9.98	2,012	1,400	1,586	5.25
England	5.35	1,756	....	1,591	5.05
France	2.23	1,238	908	1,154	3.18
United States	1.34	....	....	....	....

Sulphate of ammonia is especially valuable for the cultivation of beet-root. Its action is slower than that of nitrate of soda, but for that reason it is all the more lasting. It is absorbed by the soil and retained even after heavy rainfalls, whereas nitrate of soda is stated to be washed out. Sulphate of ammonia serves for preparing other ammonium salts, sometimes for liquor ammonia, for making ammonia-alum. A 10 per cent. solution of sulphate of ammonia is employed to render tissues, papers, etc., non-inflammable.

There are several gas-producers which give excellent results. The Mond type has been used in connection with peat in Italy and Germany. The Lymn producer is now taking a prominent position and is highly spoken of.

According to Mr. Haanel, it would be unprofitable to utilize peat for producer gas and the recovery of the ammonia unless the quantity of nitrogen is at least 1.5 per cent. of the dry sample. Fortunately, there are sev-

eral peat bogs which have been investigated having a higher nitrogen content than 1.5 per cent.

In closing this article the Holland peat bog may be referred to. It is only 42 miles from Toronto, and has an area of about 5,000 acres. The quantity of peat fuel containing 25 per cent. moisture is estimated at 8,218,000 tons, and the nitrogen content is about 2.67 per cent., based on dry sample, or about 2 per cent. based on 25 per cent. moisture standard. The calorific value of this peat (dried) is about 8,510 B.t.u. per pound. Mr. Haanel estimated the total yield of ammonium sulphate at about 507,500 tons, and, assuming 120 tons of theoretically dry peat were consumed per 24 hours, the bog would last for about 147 years. The power gas available would be sufficient to develop about 4,000 h.p. continuously for the above period.

Peat is also used as litter, possessing antiseptic properties and a capacity for absorbing nitrogenous organic matter. It is used in Germany in connection with sewage from pail closets, also for packing fruit, vegetables, etc. It may be used for insulating icehouses and steam pipes. Prof. Bottomley has succeeded in bacterizing peat, in which form it is found to be an excellent fertilizer, whilst the French make paper and cardboard from peat which has undergone but slight decomposition.

FROM CONCEPTION TO COMPLETION—THE WESTERN RAILROAD.*

By J. H. de Stein, M.C.S.C.E.

THE last few years have brought a considerable increase in railway mileage in Canada. The total of steam railway trackage in September, 1907, was about 21,800 miles, while in June, 1915, we had about 35,600 miles under operation.

Let us analyze the making of a railroad, and start with the first part of the title chosen for this paper. This demands in most cases the genius and brains of a "builder," of which creative species we fortunately had, and still have, several representatives in our Dominion.

Military reasons might demand the construction of a road, but, fortunately, we have none of these "strategical railroads," so much in vogue in the Central European empires. I would only refer to the customary procedure there, where the route plans for any railroad have to be approved by the military authorities before construction can start.

We can now summarize and classify the various lines, which classification is necessary before location and construction can proceed, as the various classes demand different treatment.

We have, first, the main line, which in itself is a completed unit. In this respect we are slightly spoiled in Canada. With our three great transcontinental systems we might think that a main line has to be several thousand miles long. None of the railway systems on this continent, outside of Canada, have a line from coast to coast—except, perhaps, the Panama Railway—and yet, of course, every system has its one or several main lines.

I would distinguish two classes of main lines. The main line of the first order, the trunk line, which is built for international or world traffic. It has its strict limitations as to grades and curvature, figuring on a quick through traffic. It can—in a settled country—neglect to touch larger towns, etc., having only one object: to gain its ultimate destination with as short a route as possible. The original survey of the main line of the Grand Trunk Pacific left settlements like Brandon, Yorkton, Regina, Saskatoon, Battleford, etc., many miles from its course. Subsequently the route was changed, bringing the line within short distance of Saskatoon. This was certainly a concession to local conditions entirely unwarranted with the original conception of a trunk line.

The main line of the second order has to consider local conditions to a larger extent. Grades and curvature can be increased, the expenditure per mile being much lower than in the former class. Length of line can be sacrificed in order to touch existing settlements, industrial properties, etc.

The second main classification comprises the various branch lines. The branch lines, by connecting cities and large settlements with a main line, ensures a considerable traffic right from the very commencement of operations

A less important class of branch lines would be one extending from some main line or branch line point to a farming, mining or timbering district without aiming for any particular point, just picking the easiest route and building as cheaply as possible.

As a rule—taking conditions as they are in the Canadian West—the settlement exists ahead of the contemplated branch line, and traffic in proportion to the expenditure can be expected right after completion of the road, though, of course, settlers will follow the railroad and by increasing the traffic and subsequently the earnings, will warrant some annual capital expenditure on betterments of the originally cheaply constructed line.

After this preliminary classification we are coming to the more concrete part of our theme: the survey, which I would group into two main parts: the financial and engineering survey.

Teachers of economics tell us that the ideal railroad would be a Government-owned line, built and operated strictly as a public utility; that is, the revenue merely pays for the operating expenses, while interest on the cost of construction and maintenance charges would have to be covered from public funds. A more modified view allows for operating and maintenance expenses to be covered from the gross revenue, while the third and commonly adopted standpoint sees in the contemplated road only a source of revenue, which, popularly speaking, centres around the question, how little money will have to be spent to get the biggest revenue from operation.

The estimate of the future prospects of the railroad seems sometimes to be treated too slightly, or we might better say, too optimistically. When I say optimistically, I do not necessarily mean that some line in question should not have been built, but that perhaps the anticipated traffic exceeds considerably the actual one; that is, the road has been built too expensively from the start.

In a new country like our West, a financial survey is very difficult and uncertain, which, perhaps, excuses to some extent the recent financial difficulties of some of our roads.

In nearly all of the older settled countries the engineer has an array of data at his disposition, while in Canada we have not had time yet to collect these.

There should be four main factors brought into consideration:—

*Abstract of paper read before the Regina Branch of the Canadian Society of Civil Engineers.

(1) Estimate of anticipated traffic.

(2) Calculation of revenue thereof.

(3) Estimate of operating expenses.

(4) Calculation of necessary capital for construction and operation.

The estimate of anticipated traffic is mostly a matter of statistics. The first reliable and simple tables were compiled by the French engineer Michel, and published in the "Annales des Ponts et Chaussées" in 1868. He concluded quite naturally that passenger and freight traffic are a function of the number of inhabitants of the tributary district, considering to some extent their mode of occupation.

While this may be tabulated and compiled in Europe and the eastern and southern part of our continent, yet it is doubtful if it would bring satisfactory results in Western Canada. Generally, of course, in our time, the settler is ahead of the railroad, but the settlement intensifies with the advent of the track, production becomes greater with easier accessibility to the markets, which all affects the traffic. Then, again, unfortunately in several large portions of our West, the population depends entirely upon the production of one commodity—for instance, grain growing. One or two successive crop failures in a district served by some railroad mean practically no outgoing and very little incoming freight.

It would be interesting, however, to compile a statement for each railroad, giving the passenger and freight traffic in tons per capita in every one of our Western provinces.

On the basis of probable volume of traffic an estimate of the revenue thereof can be made. I have some figures before me, compiled some time ago in the United States. I note that the gross revenue per head of population amounts to about $13 in the populated Eastern States and only $5 in the Southern States. Of considerable value in this respect are the tables compiled annually by the Department of Railways and Canals of Canada.

Lastly, we have to estimate the operating expenses and the necessary capital for construction and operation, which calculations can only be done conjointly with the locating engineer, except, of course, in old settled districts, where, perhaps, a new short route between two larger centres is contemplated, allowing a fairly accurate preliminary estimate of aforementioned financial points without previous or simultaneous engineering work.

Of course, a large amount of operating expenses are fixed charges, independent of the survey of the road, but it is the duty of the engineer to find a line which will keep operating expenses down to a minimum without sacrificing revenue.

SWISS RAILWAY ELECTRIFICATION.

The electrification of 67 miles of the St. Gothard line of the Swiss State Railways, now in progress, is the first step in a project ultimately to operate all the federal-owned lines in that country, aggregating nearly 2,000 miles, by electric power. The single-phase a. c. system, as is now operating on the Lötschberg line, is to be used on this and future electrifications, the commission in charge having decided that it is the only system worthy of serious consideration for a project of such magnitude. While all the usual benefits are expected to accrue from the improvement, the principal item is the economy of utilizing the immense water power resources of the Alps, thereby making the railroads independent of expensive imported fuel, there being no coal mined in Switzerland.

METHOD AND COST OF PLANE TABLE SURVEYS FOR AN IRRIGATION PROJECT.

The cost of plane tabling for an irrigation project in Alberta, Canada, was, according to a recently issued report, approximately 10 cents per acre. The work was carried out in 1915 on the Lethbridge Northern irrigation project by engineers of the Irrigation Branch of the Department of the Interior of Canada.

A party of three plane-tables was organized in Lethbridge and consisted of the following men: Field engineer in charge of party, three assistant engineers, one draughtsman, six rodmen, three teamsters and one cook, with a camp and transport equipment of 8 tents, 2 wagons, 3 democrats and 10 horses.

This party commenced field work on April 29, and finished for the season on November 22, 1915, a period of 179 working days, covering 119,015 acres of topography, which is an average rate of 221 acres per plane-table day. No account was taken of a total of 25 working days which were lost during the season on account of bad weather.

A second party of three plane-tables was put on this work in September. This party commenced plane-tabling on September 17 and finished for the season on November 19, a period of 55 working days, covering 30,500 acres of topography at an average rate of 185 acres per plane-table day.

A total area of 149,515 acres was contoured during the season and in addition 315 miles of levels were run, setting bench-marks for the plane-table work.

The total cost of surveys for the season of 1915 was as follows:—

Wages of party for the field season	$ 8,852.31
Commissary (subsistence, fuel and cook's wages)	2,918.56
Horses (hay, oats and supplies)	619.00
Miscellaneous	625.03
Draftsman (4 months extra to finish plans)	300.00
Total cost	$13,314.90
Total area plane-tabled, acres	149,515
Cost per acre, cents	8.9

Allowing a depreciation on outfit of $1,500 for the season, the cost per acre plane-tabled would be approximately 10 cents.

Each plane-table party consisted of an assistant engineer, two rodmen and teamster, the teamster acting as recorder to the instrumentman. The scale of the plans was 400 ft. to 1 in., allowing one section to be shown on each plan. Beginning with a measured base line at least 1,200 ft. long, a closed plane-table survey was made of each section. The limit of error of closure allowed was 1/20 in. in plan, which at the scale used equals 20 ft. The limit of error for plane-table levels on each section was 2/10. All plane-table stations were set by triangulation from the base line, as were also all mounds.

The greater part of the work was done by taking spot levels, over the whole area, at distances apart varying from 100 to 400 ft., depending on the roughness of the land. The contours were then sketched on the plans in the field by interpolation In giving the spot levels, care was taken to outline all sinks, knolls, drainage lines and saddle. All buildings, houses and fences were noted, also the character of the soil and the name of the owner of each parcel of land.

LETTER TO THE EDITOR.

Stone-Filled Sheet Asphalt.

Sir,—We read with interest an article on "Stone-filled Sheet Asphalt," by Charles A. Mullen, in your number of 15th instant.

Mr. Mullen makes some very broad claims as to the advantages of stone-filled asphalt, and naturally we take note of them. The advantages claimed are: (1) that it is less slippery; (2) that it marks up less in the summer; (3) it is easier of traction in the summer; (4) it is less liable to displacement; (5) it costs less.

First, as to slipperiness. That can be scarcely more than a matter of opinion. In an earlier part of the article we find the statement made that "this initial roughness passes away after one or two summers' traffic, and leaves a surface almost as smooth as that of the usual sheet asphalt." The lack of slip depends on friction combined with a relationship between the two surfaces concerned; that is, the tendency of one to seize the other. It is frequently controlled by the interposition of a third element. In roads, the third element may be water, ice or snow. Horses slip badly on granite blocks if the load behind is greater than the weight of the horse. The slight marking of a good asphalt pavement is really a desirable feature for horse-drawn vehicles, as the small amount of penetration enables the horse to use his strength with some help from the surface. Stone filling with 30 per cent. of ¼-inch chips seems unlikely to make much difference in slip on dry, bare and cold pavements. When ice and snow are present, differences of composition are not operative factors.

With reference to marking up, we have seen ordinary sheet asphalt pavements that marked up very little, and others that marked up a good deal. This condition, we always believed, was controlled by the filler and the penetration of the bitumen. In this climate we would hesitate to lay, in residential districts, a pavement that did not mark up quite noticeably in the summer.

The claim of ease of traction is, of course, dependent on the first two considerations.

The liability to displacement is important, and we certainly have seen some bad cases due to faulty binder course. We feel inclined to go so far as to say that a pavement laid badly with binder course is inferior in this respect to a stone-filled asphalt laid by the same personnel.

And now we come to the big point: it costs less. Mr. Mullen gives some very convincing figures, showing that two inches of surface mixture costs more per square yard than two inches of stone-filled sheet asphalt. What about the binder course? If, instead of two inches of surface mixture, we had one inch of close binder and one inch of surface mixture (which is quite sufficient) we could make the following comparison:—

	Ordinary sheet asphalt.		Stone-filled sheet asphalt.	
	Lbs.	Cost.	Lbs.	Cost.
Asphalt cement at $.01 per lb.	17	$.17	20	$.20
Filler at $.0025	20	$.050	20	$.050
Graded sand at $.0005	68	$.034	100	$.050
Clean stone chips at $.0008	none		60	$.048
Crushed stone, 20-mesh to ¾ in., at $.0005	95	$.047	none	
	200	$.301	200	$.348

According to Richardson, the binder course was probably introduced to protect the friable, natural cement from the necessary traffic incidental to laying the wearing surface, but it is apparent that the introduction of the binder course was quite a considerable economy. The open binder, taking less bitumen, is even less expensive, and would do well for light traffic in residential districts. A large amount of sheet asphalt with open binder course has been used in pavements under heavy traffic.

On the whole, we cannot see that Mr. Mullen has proved for stone-filled sheet asphalt that "its actual cost is so low that it is the most economical pavement for light residential streets and boulevards. It should, therefore, be adopted by most cities as the standard form of pavement. . . ." Why should it be adopted only "by *most* cities," we might inquire, by the way?

Mr. Mullen may be right in his claims of superiority, but we are "from Missouri." He makes broad statements, but he adduces no proof. The only figures given can be used to show that a two-course pavement will cost less for materials than the stone-filled one-course pavement.

T. LINSEY CROSSLEY, A.M.Can.Soc.C.E.

Montreal, February 20, 1917.

LETTER TO THE EDITOR.

Brushwood as a Medium for Sewage Filters.

Sir,—From the final paragraph of the article in *The Canadian Engineer* of February 8th, 1917, on "Brushwood as a Filter Medium for Sewage Filters," by Mr. George Phelps, it would appear as though the brushwood filter was only "the outcome of previous experiments with a lath filter," and had not been suggested by me.

In order to remove any misapprehension on the point, I would like to state that prior to the North Toronto installation the process had already been patented by myself; that the installation of a brush filter was already in hand at the Morley Avenue experimental sewage disposal plant, and that the conversion of one of the North Toronto stone trickling filters into a brushwood filter was made at my request by the commissioner of works, Toronto, to be operated as an experimental filter to obtain scientific information.

GEO. G. NASMITH,
Director of Laboratories.

Toronto, March 3rd, 1917.

Some very rich deposits of tungsten occur, it is said, in Portugal in the form of wolframite, accompanied by scheelite, and also, frequently, by cassiterite (binoxide of tin). The three principal deposits are the property of independent companies, the first, a French concern, exporting its whole output to France; the second an English company, exporting to England; and the third which is operated exclusively by Portuguese capital. The daily output of the first two averages about one ton of wolframite each, containing 60 per cent. of tungsten trioxide; the output of the other concern is somewhat less. In addition, there are numerous smaller deposits, but the output of these is not known. In 1914 the exports of tungsten ore from Portugal amounted to 1,700 tons. No figures, however, are available as to the quantity produced. At present the exportation is made under the intervention of France and Great Britain, which countries absorb the greater part of the total shipments. A small quantity is exported to the United States.

Editorial

ENGINEERS AS VIEWED BY THE CONTRACTOR.

The relation between engineers and contractors has always been a vexed question and any improvement in the harmony of their relations is made difficult because they represent opposing interests to a considerable degree. It would, of course, be unfair to expect that differences of opinion will not exist at times between these two. It is inevitable when human agencies are involved.

Contractors are in very many instances largely influenced by the opinions of engineers. The engineer who has already earned a reputation for ability, honesty, a disposition to fairness, will always attract bidders for any work with which he may be trusted.

In bidding for work contractors are about as sensitive as weather vanes. They know it is quite possible to make a profit at a given bid under one engineer and impossible to avoid a loss under some other engineer, even when all other conditions are practically the same.

Then, again, if an engineer's preliminary estimate is believed to be too low it tends to drive away bidders and to indifferent high bidding. Under such circumstances some contractors who are over-anxious for work are influenced to bid too low. They may get the work, in which event the engineer has an unpleasant task on his hands during construction. As a result, too, there is almost sure to be a disposition on the part of the contractor to save himself from loss and he is thus tempted to slight the quality of the work. In such a case both contractors and engineers are in some degree injured by the work having been done at less than cost.

The engineer who can make reliable preliminary estimates will always find his services in demand by municipalities, corporations and others.

LITERATURE AND THE ENGINEER.

One great sneer on the lips of so-called superior people is that the present is a machine-made age. Frankly it is; and of all the matters which distinguish and make the age interesting, mechanism and mechanical art generally must have a foremost place.

Each age in history is now considered as distinguished in some one direction and it is rightly assumed that those connected with each age's activity were peculiarly blessed. To be closely associated with the moving motive of the present day need therefore cause no misgivings.

The men who write for universal consumption are, in the main, apart from its leading feature. The engineer's mentality runs less to words than deeds, hence much misconception as to his real importance in the realm of books. Individual craftsmanship has given place to more intensive cultivation, needing collective effort spread through many sub-sections, each of which demand skill equal to that formerly needed in a wider sense. Team effort, organized production on an immense scale has taken the place of isolated manual dexterity. Can no writer of eminence find in such material, scope?

The historian of the future must inevitably turn to the files of the technical press if he is rightly to interpret the last few decades. The history of the world has received an indelible mark from the hand and brain of the engineer which will endure to the end of time.

Wealth, comfort and convenience have all been profoundly affected less by the speech of the politician than by the work of multitudes of unrecorded men with a common end in view. Nothing done in an engineering sense has been devoid of communal good, save that perfected engines of destruction have issued from the same source. Yet, even progress here is ultimately to end war more certainly than diplomacy. Cheap bread, cheap transport, cheap meat, cheap wearing apparel, and the thousand and one essentials which make up the material comfort of modern life have a single hand visible throughout the entire series. It is the hand of the engineer.

Literature, because of its lack of technical understanding, has avoided him—has failed lamentably to analyze his work or popularize his activities. It is high time that the engineer spoke for himself, that his overdue claims in the matter be recognized.

Technical literature of a practical order is surprisingly well done, but is a thing apart from usual literary notice. As a specialist the engineer discusses matters of a particular and not of general interest, and is penalized therefor. He uses terms and phrases not familiar. He is developing a special literature suited for particular consumption, finding keen delight in what must inevitably be puzzling to the outsider. As the activities of the engineer take a wide range the average journalist will be forced into line. He will have to understand at least the broad features of the engineering field so that he may rightly interpret for the more general public.

ONTARIO GOOD ROADS ASSOCIATION.

The suggestion that the Federal, Provincial and municipal authorities co-operate in finding employment for returned soldiers by the construction of highways was embodied in a resolution adopted at the fifteenth annual convention of the Ontario Good Roads Association held at Toronto last week.

Mr. W. Huber, assistant engineer of the Department of Public Highways, in the course of an address on "Reducing Construction Costs by Increased Efficiency," made specific mention of the various factors which governed efficient engineering, as follows: Traffic conditions, freight rates, condition of roads, labor market, etc.

In summing up, Mr. Huber said that the efficiency of road construction depended upon the systematic planning of the work, the careful supervision, the selection of the best and most responsible men, the fair treatment of the workers, and the adoption of a suitable system of records.

The following are among the resolutions adopted:—

1. That the province be asked to pay for 40 per cent. of all roads erected under the Provincial Highways Act.

2. That Legislature be asked to undertake the construction of a provincial roadway from Windsor to

Quebec, and that it be proceeded with as soon as possible.

3. That the province be requested to pay 40 per cent. of the maintenance cost of highways.

The following officers were elected: Honorary presidents, J. A. Sanderson, Oxford Station, and S. L. Squire, Waterford; president, C. R. Wheelock, Orangeville; first vice-president, J. J. Parsons, Caledonia; second vice-president, W. H. Pugsley, Toronto; secretary-treasurer, George S. Henry, M.P.P., Toronto

PERSONAL.

J. H. WHITE, lecturer in botany and forestry at Toronto University, has been appointed assistant provincial forester of Ontario.

Lieut. LEWIS WYNNE-ROBERTS, of the Royal Engineers, son of R. O. Wynne-Roberts, Toronto, left England on February 10th for Mesopotamia.

DANIEL F. COYLE, of Winnipeg, has been appointed industrial commissioner of the newly organized department of resources of the Canadian Northern Railway.

Capt. A. J. LATORNELL, A.M.Can.Soc.C.E., formerly city engineer of Edmonton, Alta., who is now at Kingston, Ont., expects to leave for overseas shortly with a draft from his battery. Mr. Latornell is captain of the 75th Battery of the Canadian Artillery.

EUGENE W. STERN, M.Can.Soc.C.E., a graduate of the Toronto University, 1884, now chief engineer of highways, Borough of Manhattan, City of New York, has been commissioned a major in the Engineer Officers' Reserve Corps, United States Army.

JOHN F. GREENE has resigned as bridge engineer for the city of Calgary and has accepted an engagement with the Carter-Halls-Aldinger Company, of Winnipeg. Mr. Greene was the designing engineer on the reinforced concrete arch bridge over the Bow River in Calgary which has just been completed.

OBITUARY.

Lieut.Col. STANLEY G. BECKETT, who went overseas in March last as commanding officer of the 75th Mississauga Horse Battalion, has been killed in action. Col. Beckett was a prominent Toronto man, having been a member of the firm of Chadwick & Beckett, architects.

CANADIAN SOCIETY OF CIVIL ENGINEERS, TORONTO BRANCH.

The regular monthly meeting of the Toronto branch of the Canadian Society of Civil Engineers will be held in the rooms of the society at the Engineers' Club, 90 King Street W., on Friday, March 9th, at 8 p.m. Capt. D. M. Mathieson, Canadian Engineers, will give an address on "Engineers in France."

The branch is particularly fortunate in being able to secure the address from Capt. Mathieson. In order to meet the schedule of the speaker the night of meeting has been changed from Thursday to Friday. Will members kindly make note of the change?

THE NEW SECRETARY OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

After serving the Canadian Society of Civil Engineers as secretary for over a quarter of a century, Professor C. H. McLeod, Ma.E., has tendered his resignation. Reference to the record of Professor McLeod and to the time, thought and energy which he has devoted to the Society during the past 25 years was made in the February 1st issue of *The Canadian Engineer*.

He is to be succeeded by Mr. Fraser S. Keith, B.Sc., A.M.Can.Soc.C.E. The new secretary was born at Smiths Falls, Ont., June 8th, 1878. He entered Faculty of Applied Science, McGill University, 1899, graduating with honors in electrical engineering in 1903. A summer thesis which he wrote won the prize in the mechanical section, Canadian Society of Civil Engineers, the paper being incorporated in the Society's transactions of that year.

After spending a year as senior demonstrator in electrical engineering at McGill University, he became

Fraser S. Keith, B.Sc.

editor and later manager of "Canadian Machinery." In 1907 he became editor of "Canadian Manufacturer." Went to Vancouver in 1908, where for several years he was engaged in the manufacture of concrete materials and concrete construction. While in Vancouver he was for six years an active member of the executive of the McGill Alumni Association of British Columbia and occupied the position of Hon. President at the time of leaving that city.

In the spring of 1915 Mr. Keith returned to the east, making his headquarters at Montreal.

During the past eighteen months he has edited "Construction," which position he leaves to take up his new duties.

Mr. Keith has always been a close student of engineering progress, particularly in its relation to the development of Canada's natural resources, and has enjoyed unusual opportunities for cultivating an intimate acquaintance with industrial conditions in practically all provinces in the Dominion.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

DON INCINERATOR—TORONTO

DETAILS OF CONSTRUCTION AND METHODS OF OPERATION OF PLANT—CAPACITY OF ONE HUNDRED AND EIGHTY TONS OF REFUSE PER DAY WHEN FULLY OPERATED

BUILDING operations in connection with the Don incinerator plant are rapidly drawing to completion. It had been hoped that the plant would have been in operation long before this. Unavoidable delays, however, incident to the scarcity of experienced labor and the delivery of materials have resulted in the estimated time for completion being exceeded. At present the main part of the building is completed, and the furnace contractors are now engaged in the drying-out operations on the furnaces, so that it is expected that the testing out of the furnaces will take place at an early date. If these prove satisfactory the city will accept the plant, and proceed with its operation immediately.

Looking from Wilton Avenue Bridge.

The main building was constructed under a general contract, and was designed and supervised by the city architect's department. Contracts for the pile-driving, concrete foundations, furnaces and appurtenances, radial brick chimney and foundations for same were awarded and supervised by the department of street cleaning. The excavations, grading, etc., were carried out by day labor.

The pile-driving and concrete foundations for building and furnace contracts were completed by the end of December, 1915, as was also a portion of the furnace contract. Owing to delay in the delivery of steel, all work was practically held up until March 1st, 1916, when erection was started on the steel framing for the building. From that time to the present, work has progressed slowly but continuously.

The building, which is of fireproof construction throughout, is built of brick, steel, stone and reinforced concrete. It is located on the east side of the River Don, immediately north of Wilton Avenue, and consists of five floors at various elevations, *viz.*, tipping, charging, stoking, main and ash run floors.

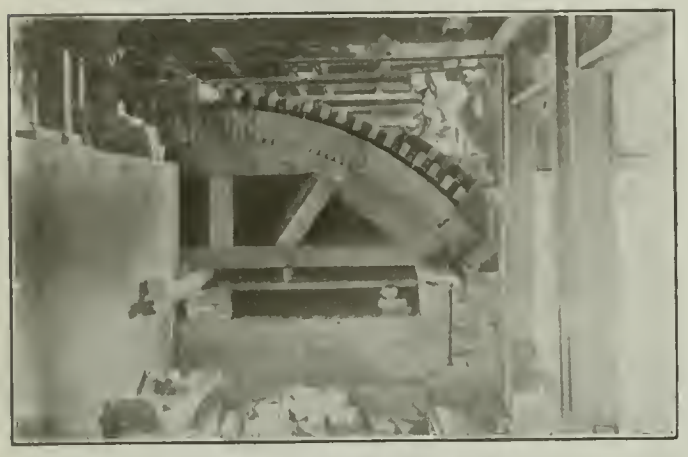
The elevation of the tipping floor is on a level with Wilton Avenue, the main floor being some 33 feet below on a level with the Don Roadway, while the intermediate floors are known as charging and stoking, from which floor the furnaces are charged and fired respectively. The ash run floor is located on the west side of the building and is immediately below the stoking floor. The building at the tipping floor level is connected at the northeast and southeast corners to Mount Stephen Street and Wilton Avenue respectively, by means of reinforced concrete bridges. The north bridge at the building extends in a westerly direction parallel with the north end of the building and connects with the ash section which is located at the northwest corner of the building. Its purpose is to receive the residue from the furnaces as well as ashes, etc., collected from the districts in the vicinity of the plant. This building has two floors, *viz.*, tipping and bin, the tipping floor being level with the like floor of the main building. The bin floor is located some few feet below, and has laid thereon a narrow-gauge track with turntables, the arrangement being similar to that laid in the ash run. On the west side of the ash building a steel bin of large dimensions is suspended, which is equipped with a series of steel adjustable chutes. These allow the ashes, residue, etc., to be loaded into cars on a railway siding below. The railway siding is laid parallel with the west side of the building and passes through the ash building. The main building is 151 feet long by 81 feet 6 inches wide.

The plant is equipped with three high-temperature "Sterling" furnaces of modern design, which have been installed by the Canadian Griscom-Russell Company, Limited. There are three furnaces of four units each. Each furnace has a grate area of 25 square feet, and a guaranteed burning capacity of 50 lbs. of refuse per square foot of grate area per hour, and is therefore capable of totally incinerating 5,000 lbs. of refuse per hour or a total capacity of 180 tons per day of 24 hours with the three furnaces in operation. It is reasonable to assume that the burning capacity will be exceeded, when operating under normal conditions, as the contractor's

guarantee is undoubtedly based upon the plant operating under the worst possible conditions.

It is the intention to operate the plant on a two nine-hour shift, two unit basis, the third unit being held in reserve. By this mode of operation it is anticipated that approximately 100 tons of refuse will be disposed of each day.

The specified requirements of the furnaces are such that the temperature in the combustion chamber shall not fall below 1,250° Fahrenheit for a greater duration than three minutes in any one hour, and that an average tem-



Detail of Combustion Chamber.

perature of at least 1,400° Fahrenheit shall be maintained. At the above temperatures, possible objection due to the presence of obnoxious gases will be entirely eliminated, inasmuch as all gases generated from the incineration of garbage are rendered odorless at a temperature of 1,050° Fahrenheit. It will thus be observed that the specified temperature affords a leeway of at least 200° Fahrenheit. Provision is made for the registration of the temperatures of each furnace on a daily chart by means of a continuous electrical recording pyrometer.

Blowing System.—Each of the furnaces is provided with an effective, induced, superheated draft system,

Early Stages in Construction.

generated by means of a direct-connected motor-driven fan. The air being drawn from the top of the furnace front by the fan, is forced into the regenerating chamber of the furnace, and whilst passing through this chamber it is raised in temperature. From the regenerator it passes into the airduct of the furnace at a temperature of not less than 300° Fahrenheit. The admission of air under the grates is regulated by means of valves operated conveniently from the furnace front.

The furnace charging devices are placed on the furnace tops, and consist of a steel container for each cell, into which the material is fed, the containers and charging doors being opened and closed mechanically by the use of hydraulic rams which are also placed on the furnace tops. These rams are operated under water pressure, controlled from the stoking floor level.

The furnace and flues are lined throughout with firebrick 9 inches in thickness; the outside walls being of suitable thicknesses, are constructed of common brick, faced with the best quality of salt-glazed brick. These bricks, being of a non-absorbent nature, were specified so as to permit of the brickwork being washed down, their glazed surface conducing to the maintenance of the furnaces in a clean and sanitary condition. Heavy buck-stays of structural steel are spaced at frequent intervals throughout the furnace and flue structures and are rigidly tied together with steel tie-rods. An air space of at least ¾ inch between the lining and outside walls has been maintained throughout and vented at frequent intervals, thus permitting a continuous circulation of free air, thereby minimizing the transmission of the temperature of the lining to outside walls.

The operation of the plant is simple. The material is brought into the building over either of the bridges to the tipping floor, which is spacious enough to allow the free passage of wagons while others are dumping their loads. The wagons are backed against a bumper beam on the west side of the tipping floor and the material is dumped to the charging floor, some eight or nine feet below, where it is charged into the containers. From the containers it passes through the charging door on the furnace top and drops, at the will of the firemen, to a firebrick drying hearth located at the back of the furnace. A large percentage of the moisture is here absorbed from the material, which is then drawn over the grates, where incineration takes place. The flame and hot gases from the refuse pass into the combustion chamber, where total combustion is effected. From the combustion chamber a portion of the gases pass through the cast-iron regenerating tubes, and discharge into the connecting flue at the top; the remaining gases are carried through a by-pass flue and enter the connecting flue at the bottom of the uptake. The amount of gases passing through the regenerator is controlled by a damper. From the connecting flue the total products of combustion pass into the main flue, and thence into the chimney. Clean-out doors are placed at convenient points and afford ample means of removing dust accumulations from all parts of the furnaces and flues.

The clinker or residue from the grates is removed from the stoking floor level through the doors at the front of each furnace, and is dropped through a series of trap doors on the stoking floor into dump cars which operate on the industrial track in the ash run below. These cars are conveyed to the north end of the run where they are elevated by an electric elevator to the bin floor level of the ash building, where its contents are dumped into the ash bin, from which they may be loaded into cars or wagons as desired.

The radial brick chimney is located some 25 feet distant from the east wall of the building. The sub-foundation which supports the concrete foundation and structure consists of piles driven "to refusal," approximately 40 feet into the ground. Upon this foundation the octagonal base 25 feet in height is con-

structed of brick of the same quality and laid in a manner similar to that used in the main building. The radial portion of the chimney is built upon the base, and towers to a height of 150 feet, thus giving an over-all height above the foundation of 175 feet. The outside diameter of the radial portion at the base is 16 feet 9 inches, and from that point to the top it tapers to an outside diameter of approximately 10 feet 2 inches. The firebrick lining, which is 7 feet 6 inches inside diameter, is constructed in four sections, varying from 13½ inches to 4½ inches in thickness. It is self-supporting, and is constructed with four pilasters and extends from the foundation to the top of chimney. At the base of the chimney a large damper is provided. Each furnace is also provided with individual dampers, which may be closed when desired.

The estimated cost of the plant complete is approximately $200,000.

The furnaces and appurtenances and the radial brick chimney and foundation for same are guaranteed for one

Front View of Furnaces.

and five years respectively. In each case percentages of the contract prices are retained for the period of one year, and bonds satisfactory to the city treasurer have been furnished to cover the above-mentioned periods.

The services of two foremen and twenty-eight men are the estimated labor requirements necessary to operate the plant on the basis as previously stated.

Despite the fact that the ownership of the site of this plant has been vested in the city for a period exceeding 30 years, during which it remained an unkempt weed-bestrewn waste, affording a dump for all sorts of refuse material, violent objection was encountered by the department in securing it for the legitimate municipal purposes for which it is so naturally adapted.

The department's contention that the plant would in no way detrimentally affect the neighborhood, but would, on the contrary, improve the locality, has been amply demonstrated.

The once veritable waste, with its rugged refuse-bearing banks of slimy mud, has already given place to symmetrical slopes and terraces on its southern aspect and similar treatment will be accorded the lands to the north of the building as soon as weather conditions permit of the work proceeding.

The building itself, from an architectural standpoint, is unsurpassed, if not unequalled, by any industrial structure in the city, and reflects credit on the city architect and those of his department more immediately concerned in its erection.

An effective surface drainage system has been laid around the building for the purpose of disposing of the vast amount of surface water that is shed from the surrounding banks and yard area.

From the ideal location and the many points of access to the plant, the traffic on any individual street leading thereto will be reduced to a minimum; the approach bridges and tipping floors are to be paved with wooden blocks, thus the noise of wagons entering and leaving the plant will be greatly reduced.

CANADIAN SOCIETY OF CIVIL ENGINEERS, TORONTO BRANCH.

At a meeting of the Toronto Branch, held in Engineers' Club, Friday evening, March 9th, 1917, Capt. Mathieson, of the Canadian Engineers, gave what proved to be an exceptionally interesting address on "The Work of the Canadian Engineers in France." Capt. Mathieson left Canada with the first Canadian forces as a subaltern in the 2nd Field Company, and is now in Canada on sick furlough. He was at the front for over seventeen months, and won the Military Cross for his good work in a number of the engagements in which the Canadians took a prominent part.

Capt. Mathieson told in a very graphic way of the importance of the engineer's work in this war. In the first few months the Royal Engineers in the British Expeditionary Forces carried on the prescribed work of the engineer in battle, i.e., the construction and demolition of bridges, etc., helping the infantry in preparation of field works, etc., but it was not until the settling down to trench warfare that the real importance and value of the engineer became apparent, and when the first contingent of the C.E.F. landed in france, the Royal Engineers were beginning to receive adequate status in the British army. This did not extend to the Canadian divisions at first; but because of the excellent work done by the Canadian engineers from the start, they soon established for themselves a very enviable status in the C.E.F., so that at the present time not a stick of material can be secured by the Canadian army in France without the O.K. of an engineer officer; and the sapper (private in engineers) is a foreman of "working parties," each party consisting of from 50 to 150 men.

Capt. Mathieson described the make-up of the line of trenches stretching from Belgium to Switzerland, and pointed out that the system of trenches practically constituted a city, and eliminating luxuries, all the engineering work handled by a works department of a city was duplicated in some way at the front, the work having to be done under very adverse circumstances, as well, of course, was the work necessitated by the activity of the enemy. For instance, the water supply for troops was one of the big engineering problems. The speaker told of one of his personal experiences in estimating the water supply in a certain section. He went round with an interpreter trying to determine the water consumption in dry season; and one French woman said that there would be plenty of water for the troops if those Englishmen didn't wash so much.

The organization of the Canadian Army Corps was outlined, and also the Canadian Engineer organization. The following outline of the Engineer organization gives a good idea of how engineering work is taken care of:—

The chief engineer, Canadian Corps, is a Brigadier-General. He has under him the four Colonels in com-

mand of the four units of Divisional Engineers, each consisting of 1 Divisional Engineer Headquarters and 3 Field Companies. He also has directly under him all corps troop companies and independent engineer officers attached to his staff who do the miscellaneous engineer work required behind the G.H.Q. lines.

Corps troop companies and the engineer officers attached to chief engineer's staff, look after the installation of water supplies for all units billetted behind G.H.Q. lines; look after the construction of G.H.Q. lines, construction of strong points between G.H.Q. lines and subsidiary lines; look after special railroad construction immediately behind G.H.Q. lines for the use of artillery; construction of all roads in the corps area up to the G.H.Q. lines, and all main roads from there forward to the most advanced point of motor transport; look after the construction of artillery route roads (both highway and railway) for supplying the heavy artillery with ammunition.

The C.R.E. (or Colonel of Divisional Engineers) has at his command divisional engineer headquarters, three field companies, the ordering of the work of one pioneer battalion and one tunnel company. He usually attaches one field company to each infantry brigade to aid them in carrying out the work in their area. The work in their area consists of the maintenance of the front line; communications to the support line; the support line; communications to the subsidiary line; and all strong points between the subsidiary line and the support line. In some instances they are given the maintenance of the subsidiary line to look after. The working parties for this work are supplied by the brigade in the line and are directed by the field company attached to the brigade, but, in addition, this field company looks after the construction of all new lines in front of the subsidiary line which may or may not be built by working parties supplied by the brigade; the construction of the subsidiary line, which is usually constructed by troops supplied by division; the construction of strong points immediately behind the subsidiary line by working parties supplied by the division; the digging of wells in the billeting area of the brigade; the construction of roads in the brigade area which are not main roads looked after by corps, and the construction of huts for billeting reserve battalions of brigade; construction of routes for the use of working parties in dry weather; and all the innumerable drainage schemes required in the rear brigade area, also the construction of light railroads in the brigade area. At the same time, considerable portion of the personnel of this company may be working under C.R.E. for construction of such things as divisional bath-houses, Y.M.C.A. recreation huts, etc.

The C.R.E. usually splits up his pioneer battalion by keeping one company to work directly under his own orders and attaching each of the other three companies to a brigade to work under the orders of the respective field companies. The tunnelling company works directly under the orders of the C.R.E., and is supplied with material and working parties by the field company in whose brigade area the tunnelling company may be operating. The C.R.E. for the construction and maintenance of the works looked after by him also gets working parties from corps troops, such as battalions in corps reserve, dismounted cavalry, and any other units who may be at the disposal of corps and lent to division.

The lecturer emphasized the point that engineering work at the front was carried on by "working parties" drawn from the infantry and pioneer battalions, a "sapper" from the engineers being in charge of each working party. The sapper must, therefore, be the foreman type—a man who can handle men and lay out work. The engineer N.C.O. has charge of his sappers, and therefore of a number of working parties; and the engineer subaltern in a field company has charge of the engineering work in the front, held alternately by two infantry battalions.

Capt. Mathieson described the interesting features of trench construction, construction of strong points, splinter-proofs, dug-outs, etc.; and told of the large amount of standard engineering material needed in this work, which standard material was made up in the engineer parks in the rear. These standard materials include splinter-proof frames, dug-out frames, "A" frames for trench riveting, bath mats, wire entanglements, etc. This engineering material is made up by working parties of tradesmen under supervision of sappers; and is brought up to the trenches by horse transport and by carrying parties. He outlined some of the dilliculties met with by the engineers in siting trenches in ground which had been contested again and again, resulting in the mud being many feet deep and interlaced with miles of wire entanglement, steel beams, corrugated iron, rilles, shell splinters, bodies, trench revettment, etc. To get a line of trenches fightable in ground such as this, doing the work at night in the dark, is no child's play.

Capt. Mathieson concluded his talk with a strong appeal to every one present to get at least one man of the type required as a sapper in the engineers interested, so that he would see Lieut. Armer at the Armouries, Toronto, and enlist in the Canadian Engineers.

RAILWAY EARNINGS.

The following are the weekly earnings of Canada's transcontinental lines during February:—

Canadian Pacific Railway.

	1917.	1916.	Inc. or dec.
February 7	$1,890,000	$1,876,000	+ $ 14,000
February 14	2,180,000	1,912,000	+ 268,000
February 21	2,225,000	2,093,000	+ 132,000
February 28	2,537,000	2,665,000	— 128,000

Grand Trunk Railway.

February 7	$ 928,462	$ 937,937	— $ 9,475
February 14	828,671	957,195	— 128,524
February 21	956,487	949,490	+ 6,997
February 28	1,129,386	1,174,099	— 34,713

Canadian Northern Railway.

February 7	$ 493,600	$ 429,400	+ $ 64,200
February 14	602,000	453,100	+ 148,900
February 21	598,700	559,000	+ 397,000
February 28	664,300	647,700	+ 16,600

Wallace and Tiernan Co., Incorporated, 137 Centre Street, New York City, manufacturers of chlorine control apparatus and scientific engineering specialties, announce the following changes in their organization, and additions to their technical staff: A Chicago office has been opened at Peoples Gas Building, Michigan Blvd. and Adams St., Chicago, Ill., Room 550, with Mr. C. A. Jennings in charge. Mr. Jennings is well known to waterworks men through his connection with the Bubbly Creek Filters of the Union Stock Yards, and his research work in the field of water purification, particularly along the lines of chlorination. Mr. H. K. Davies will be transferred from the New York office to Chicago as assistant engineer to Mr. Jennings. Mr. J. C. Kaelber has been appointed to the technical staff as assistant engineer. Mr. Kaelber is a graduate of the University of Rochester and formerly connected with the Western Electric Co. Mr. R. V. Donnelly has also been appointed to the technical staff as assistant sanitary engineer. Mr. Donnelly is a graduate of Columbia University and formerly connected with the New York Continental Jewell Filtration Co.

AGRICULTURE AND THE ENGINEER

ABSTRACT OF AN ADDRESS DELIVERED BEFORE THE OTTAWA BRANCH OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS BY HON. MARTIN BURRELL, MINISTER OF AGRICULTURE

WOEFULLY deficient in engineering knowledge, I have a whole-hearted admiration for the work of the engineer and what it stands for. It has been cynically said that a man with a powerful voice, and rapid utterance, no matter what he says, can attain a high authority in politics. I cannot, of course, be expected to subscribe to such a half truth, but, in any case, the engineer does not achieve authority in this way. He is a doer and not a talker, and in the long run it is doing and not talking that counts.

To be an engineer in the best sense of that word a man's whole attitude to his life work must be charged with sincerity, and sincerity is one of the fine things of life. Nature and nature's laws cannot be cheated. Successful achievement is only possible by understanding and co-operating with the eternal laws of the universe. There is, therefore, a continual incentive to clear thought and high endeavor. Difficult problems the engineer must face—as we all have to face, but, in solving them, he has the supreme satisfaction of knowing that his accomplished work abides, a silent and powerful witness that he has not passed through this world in vain.

I think, gentlemen, it must be easier for an engineer than for a man in public life to stick to his ideals. We cling to them as long as possible, but find them hard to attain. Too soon it becomes like the case of the Irishman with his pig. When he killed his pig he said, "It didn't weigh as much as I expected, and I never thought that it would." Nevertheless, it is good to cherish even unattainable ideals.

By virtue of being engineers you are specialists and I envy you the ability and the opportunity of giving undivided thought to the one task which, for the time, is yours. Our fate is different—a kaleidoscopic change of tasks, with no time to concentrate on any one of them. Democracy, as many understand it, implies the right of free access at all times to those who are carrying on the affairs of State. You reach your office in the morning and find a bulky mail, to which two hours' undistracted attention should be given. In half an hour your secretary announces someone who insists, without previous appointment, on discussing a nice, brief, compact little question like that of oriental immigration. Your visitor points out the transcendent importance of this subject to the future of Canada and the Empire. You may have given this subject some careful study, but, convinced of the futility of either giving or receiving anything of real value in a quarter of an hour, you nevertheless give the quarter of an hour. The mental slate sponged clean, you turn back to the correspondence. Ten minutes pass, when another member of the democracy is announced. You fume inwardly, but are told he has travelled 1,200 miles to see you and the matter is urgent and important. He is shown in and at some length, and with great vigor, informs you that in respect to a certain matter he has been treated so rottenly that, unless reparation is at once made, neither you nor your government will last longer than a cat in h——. We are, in a sense, engineers of the State. Gentlemen, don't you think we deserve credit if, under these circumstances, we can still call ourselves "civil" engineers?

And now, as I have exhausted my time and possibly your patience, I turn to my title, "Agriculture and the Engineer." If directly engineering has little to do with agriculture, indirectly its relationship is vital. It would hardly be too much to say that agriculture and engineering are, of all professions and arts, the most important to the world at the present moment. As an agriculturist, my chief contact with engineering work has been in connection with irrigation. In the large western district with which I am especially familiar, the work of the irrigation engineer is indispensable to successful agriculture. Water, the conductor of food to the growing plant and a necessary constituent of the mature plant, whether fruit or vegetable, is a vital factor. In addition to the immense evaporation through plant respiration, 40 or 50 tons of water per acre will be evaporated from the soil itself on a warm and windy day. With a rainfall of only 8 to 12 inches per annum, it is easy to see where the irrigation engineer comes in. I bear testimony to the immense value of his services in those districts where I have had personal knowledge of his work, and if I had time I could indicate what you are doubtless familiar with —the vast areas of the world's surface in India, Australia, Japan, United States and other countries which have been made to serve man's needs by the skill, the efficiency and the integrity of the engineer.

Undoubtedly the engineer's services to agriculture are incalculable. Without his work in the construction of railroads, bridges and roads, the produce of the agriculturist would be unavailable to man. There are many other ways in which the engineer's services are of immense use; I do not think it is necessary for me to dilate on them. Engineers and agriculturists, we are all aiming at the same things; that is, to produce, and to reduce the cost of production. Your function, perhaps, is more concerned with the latter than with the former purpose. I have heard it said to-day—I think it was your chairman who said it—that one of the functions of engineering was that any engineer could make a dollar go farther than a fool could two dollars. One of the functions of agriculture is to make two blades of grass grow where only one grew before. There is an intimate relation between the services that the engineer and the agriculturist can render to the State. When I think of the vast northern country that is familiar to me, all up through Cariboo, for instance, where for something like forty or fifty years men were living and toiling and producing two or three hundred miles away from what we know as a modern system of transportation, and when I come into contact with the people in that region, I get an evidence of what the engineer's work is by the longing they all have for better and easier modes of transportation, and I realize how intensely important the work of the engineer is, even to agriculture.

To one who has lived as I have in British Columbia, the indebtedness to the engineer must be ever present. Again and again as I have travelled through the moun-

tains, at times almost on the roof of the world, looking down from a slender span of steel to the vast depths below, I have paid a silent tribute to the arduous labors and the marvelous skill of the men who had the courage to go out into the wilderness and build those monuments of human enterprise and human activity. I do not think any man who has travelled through British Columbia can help but pay a most unqualified tribute of admiration to the construction engineers who have done that work for the far West.

After all, it was something more they did than to build railroads. When the roar of the first Canadian Pacific train was heard through the canyon of the Fraser, it meant not only that a great highway had by engineering enterprise been built, by which people could transport their produce or go from one point to the other; it had a higher, a moral, a national value, in the sense that the work of the engineer was the great work that bound brother to brother and made the solidarity of this people from the Pacific to the Atlantic an accomplished fact.

I fear, gentlemen, that perhaps I have already talked too long. I desire again, before I sit down, to express my pleasure at being with you to-day and my wish for the greatest possible success to this branch and to the work of your whole Society. At a time like this, when the shadow of a great conflict is upon the minds of all, when we in Canada and the people of the allied countries wake up from morning to morning not knowing what gruesome or terrible thing may happen next, when all minds are tense and all energies are strained, when perhaps at times we get impatient, critical of each other, sometimes not any too wisely, and especially when the demand for service of the highest kind is upon us all, it must be, I am sure, an immense satisfaction to you gentlemen who are engineers, as it is to me, to know that so magnificent a showing has been made by your own brotherhood—that almost 25 per cent., as I understand, of the members of the Canadian Society of Civil Engineers have taken up the burden and are now fighting or otherwise rendering service at the front.

When England to-day is under such a shift that she is ploughing up her beautiful parts, is enlisting the services of women, and disabled soldiers, in the determined effort that if her supplies are cut off, or partially cut off, she may produce more than she ever produced before, we can understand the part that agriculture is playing in this war. But engineering is playing no less vital a part, for without the services of the engineers the advance and the achievements on the western front, or on other fronts, would have been absolutely impossible. We may say almost that this is a war of science and invention. The methods of old-time battles and old-time wars are long passed out of existence, and modern skill, modern ingenuity, modern brains are essential. Those of the engineers have been called into requisition and will unquestionably play a leading part in the triumph which sooner or later must come. I can only say, in sympathizing with you and in congratulating you upon the contribution which your own Society has paid, by the heroic sacrifices that your members have made in direct participation in this war, that there remains for us who are staying behind, who have not gone, whether we be engineers or whatever be our calling and our work in life, there remains for us the supreme duty of doing all we can to strengthen the hands of those who are fighting our battles, and to build up this nation along true and permanent lines. And in such a work, Mr. Chairman, I am absolutely sure that the engineers of Canada will play their part.

EARTH AND GRAVEL ROAD MAINTENANCE.*

By A. McGillivray, A.M.Can.Soc.C.E.,
Highway Commissioner, Manitoba.

MAINTENANCE, as applied to roads, means the act of preserving or keeping these roads in a particular state or condition attained by proper construction. Repair is the act of restoring to a sound or good condition. Repairs are very often necessitated by the lack of maintenance. Thus there is a wide difference between the two operations. The importance of maintenance cannot be overestimated, because no type of road was ever constructed or possibly ever will be constructed that is entirely permanent.

It should also be thoroughly understood that a road should be built before it is maintained. The necessity of maintenance will usually commence as soon as the road is completed. Especially is this true on earth and gravel roads. Money is often spent under the so-called name of maintenance in an effort to keep open for traffic, an improperly designed or only partially constructed road. There is little or no excuse for this in a well-organized municipality; and it is entirely wrong in principle. There are many agencies, such as the action of the elements, the narrow tires of wagons, the steel-shod hoofs of horses, the driving wheels of heavy automobiles and trucks combining to displace and destroy materials in a road and to hasten the process of deterioration, that the greatest care should first be exercised in forming these materials into a properly designed road and then preserving the structure in good travelling condition. It is only by a thorough appreciation of these facts that older countries have been enabled to attain such excellent roads as they now possess, and which have made them the objects of emulation by other countries seeking to create systems of highways that will meet the requirements of modern-day traffic.

It is generally conceded as good financing to issue long-term debentures (say, for 20 or 30 years) for the purpose of creating a fund to construct roads, but no plan of road improvement is complete no matter how well the many factors entering into its construction may have been considered that does not provide for the inevitable necessity and expense attached thereto of maintaining these roads once they are brought into existence. The futility of not doing so must be apparent to anyone who has given the subject the slightest businesslike consideration. The drainage ditches, culverts of durable materials and the earth road bed if properly constructed are the most permanent features of a road, and can possibly be classed as permanent works. But even these will require certain attention to ensure the continued performance of their respective functions. Gravel, broken stone or any of the other numerous road surfacing materials are directly subjected to the destructive agencies that tend to destroy a road, and the value and usefulness of these materials would soon be lost if left without any care or attention in offsetting these destroying influences. It can be truly said that the amount of road construction undertaken by a township, county, municipality or province should be measured by the ability of such organization, financially and in other respects, to maintain the roads after they are constructed. In this way only can expenditures for this work be safeguarded, and the greatest benefits accrue from money and energy spent.

Good maintenance comprises such works as the cutting of weeds that persist in growing along the roadsides

*Paper read before the Manitoba Good Roads Association.

the removing of silt, rubbish and other obstacles that impede the flow of water in the side ditches and through culverts, the filling up of ruts and depressions that continually develop in the surface of the road. To these may be added, in the cases of earth, gravel and stone roads, the replenishing of the surface at necessary intervals with materials to replace what has been destroyed by traffic and other elements removed therefrom in the form of dust and mud.

Weeds and brush, if permitted to grow along the highway, are, to say the least, unsightly. Their existence is also a menace to the proper drainage of the road surface, as they interrupt the flow of water on the road to the side drains and prevent it from escaping quickly to the outlets. They are also a source of obstruction to the flow of water through culverts and it is a common occurrence on poorly maintained roads to see culverts almost wholly choked up with a heavy growth of weeds and grass. Heavy snow drifts with the well-known results of impassable roads during the winter months, are also attributable to weeds and brush that are permitted to grow unchallenged along the roads. These snow-drifts have also their injurious effect upon the roads in the spring of the year, by the delay caused in the opening up of the drains and by the increased moisture on the road from melting snow. It is important, therefore, to keep the roadsides clear of this rubbish which can easily be done with the assistance of a mower. The encouragement of the growth of some suitable grass, say, white clover, along the roadsides might profitably be considered, as a preventive to the growth of noxious weeds and also as a protection to earth embankment against erosion by water and the continual wash of heavy rainstorms.

When we consider the importance of drainage to the welfare of any road, nothing should be left undone within reasonable bound to keep the system in as perfect a condition as possible. Drains, if neglected, will become filled up and obstruct the free flow of water through them. Very frequently some small obstruction in a drain if not removed will accumulate a mass of debris and sediment behind it, that will in a short time create a veritable dam. A vigilant watch should be kept over the drains to see that they are performing their work. Evidences of silting and the formation of obstructions caused thereby can be detected after the water from a rainstorm has subsided and by the presence of pools of water in the bottom of the drains. The removal of a few shovelfuls of earth will often be all that is required to give the water a free passage through the drains. Road culverts should also be carefully examined, especially before winter sets in, to see that they are free from obstructions and in a position to carry off the spring freshets. A great deal can be done also in the spring of the year in assisting the drainage of roads by opening up the ends of these culverts which become filled with snow and ice during the winter and usually remain in a frozen condition much longer than in the more exposed portion of the ditches.

The effect of traffic on an earth or gravel road is the development of ruts and depressions in its surface. This is considerably augmented on a country road by the drivers of vehicles following one another in practically the same line, thus making a track on each side of the centre of the road. While it seems quite a natural thing for traffic to use the centre of the road, still drivers are sometimes forced to do so on account of excessive crown on the surface which places his vehicle in an uncomfortably inclined position for riding if he drives on either side of the centre line. A road should be given sufficient crown and only that amount to shed the water that may fall on its surface. A fall of one inch to the foot will be enough for that purpose and will also leave the sides of the roadway sufficiently flat for comfortable travelling.

To counteract the effect of traffic on the road by preventing as far as possible the cutting of its surface into ruts and depressions with its consequent injurious results on the whole structure, is the one great problem involved in the maintenance of earth and gravel roads. It must be prevented from lying on its surface until it is absorbed into the foundation soil. If permitted to do so, the destruction of the whole road is only a question of a short time.

The split-log drag or an equivalent drag is a very useful implement for maintaining a smooth surface on an earth or gravel road. It is also inexpensive and easy to handle. It should be light, and hauled over the roadway at an angle of from 30 to 45 degrees with the centre line. The dragging should commence from the sides of the roads, moving only a small amount of earth towards the centre with each operation. The road should be dragged after each shower of rain and at such a time when the earth will move freely and still contain enough moisture to pack solidly. Dragging a road when the surface is dry and hard is of litttle avail and is usually a waste of time and money. No one should know better than the operator the proper time to drag a particular piece of road. Experience is certainly the best teacher in this respect. If he applies good commonsense practice in handling the work, success will attend his efforts and it is only by doing this that the results of his labor will be satisfactory.

A municipality should have in operation some definite policy of maintaining at least its main highway. Without doubt the best system for all roads is one that provides for the continuous employment of men who could have charge of certain sections of roads, and who would become expert at the work. It is obvious, however, that the cost of carrying out such a system would be more than the financial standing of a great many districts will permit. But there is no municipality so poor that it cannot afford to put into practice some form of systematic maintenance on its main travelled roads. A few men working continuously on the roads will accomplish more real good for the same outlay of money than a correspondingly larger number working intermittently for short periods. For instance, the service of one man on a stretch of road for thirty days will be of more real worth than that of thirty men for one day.

In a rural district and especially so in the prairie provinces where the earth road is and will be for many years the predominant type, a method suggested for the care and upkeep of these roads and one that appears to be practical and productive of the most satisfactory results, is that the council of a municipality divide its main highways into sections of at least two miles or at the most three miles in length. Contracts should then be arranged with the nearest resident to each section to drag such stretch of road during the whole open season and until freeze-up in the fall, the council furnishing him with a drag with which to do the work. The contract price should be based on a fixed sum per mile of distance travelled by man and team for each operation. The road commissioner, who in many of the western municipalities is the councillor for the ward, should see that the dragging is done whenever it is required. Information as to the condition of the road, and the need of dragging can be obtained by using the telephone, which system is now

so well established in all the settled districts. A record of the work can be kept by the dragger after each dragging. This report would show the number of rounds made over the section of the road, the miles travelled in doing so, and when certified by the road commissioner or councillor would constitute a voucher for payment. This plan has been adopted in the State of Minnesota and in at least one of the municipalities of this province with splendid success. Needless to say, the active co-operation of the resident farmers and their willingness to undertake and perform the work are essential to the success of the scheme. The number of times a road should be dragged varies with the seasons and the nature of the soil. Heavy retentive clays will rut much easier than lighter soils with better natural drainage. The whole drainage system of the road influences in a marked degree the problem of maintaining a smooth, properly crowned surface. On an average, an earth road will require to be dragged about twenty times during the season. One trip over the road each time is usually all that is necessary. At any rate, an effort should be made to keep it from rutting so deep as not to require more than one application to restore an even surface. Should the road become deeply rutted during a protracted rainy season, it will sometimes be necessary to use a blade grader to trim the shoulders of the road and crown the surface into proper shape again before using the drag.

A gravel road will not require as much dragging as an earth road, especially after it has been used for a year, and the gravel has become thoroughly compacted. However, during the wet season, ruts will develop under heavy traffic, and the drag will be found most useful in restoring a smooth surface. Stones, which become loosened, or have not been securely incorporated in the gravel, should be removed from the roadway. If left lying about on the surface, they are most annoying and discomforting to the users of the road. They should be raked in piles and removed to the sides of the right-of-way. They can very often be used to good advantage in rip-rapping the ends of culverts as protection from erosion.

Undoubtedly the best results in the maintenance of a gravel or stone road can be obtained by the continuous employment of labor during the season. The road should be divided into sections about six miles long with each section assigned to the care of one man. This man should be equipped with a rake, shovel and wheelbarrow. Small piles of gravel should be distributed along the road at frequent intervals, so that small depressions or holes can be filled in and levelled up before they assume larger proportions. Once a depression begins to form in a road surface, its growth is accelerated by the action of vehicles bumping into it. Such a place should receive immediate attention by filling in a little fresh gravel and restoring the surface to a uniform elevation. Under no circumstances should the road be permitted to become covered with depressions and bumps. But an even surface should be maintained and the road and vehicles travelling over it thereby protected, and which would also add to the comfort and pleasure of those using it.

A gravel road will require additional material placed on its surface from time to time to replenish that worn off by traffic. The amount required and the frequency of such renewals depends upon the care given to the general maintenance of the road and the amount of travel on it. The best time to place new gravel on a road is in the spring of the year. The seasonal rains and moisture will assist greatly in binding the new gravel to the old surface and consolidating the whole mass. Lighter coatings at one time with more frequent applications will be more economical than allowing the gravel to wear down to such an extent as to necessitate a heavier coating to restore it to proper thickness.

A lively interest should exist in every community in connection with keeping the roads in a properly maintained condition. The awarding of a small prize for the best kept road in a municipality has a tendency to promote this desired effect and to create a friendly rivalry among the residents in keeping their respective roads up to the highest standard. The work of the Manitoba Good Roads Association in carrying out its annual competition for the maintenance of roads with the split-log drag is commendable and has done a great deal to encourage the using of this implement throughout many of our municipalities.

The Department of Public Works has issued regulations whereby a municipality will be assisted financially to the extent of $2.50 per mile of road maintained during the season by the split-log drag under a properly organized system, and also in appointing a demonstrator to explain in a practical manner the best methods of using the drag. More municipalities should avail themselves of these advantages and place their roads under some organized system of maintenance.

The securing of good roads is first the application of the best principles in construction and constant vigilance maintained.

ROAD SUPERINTENDENT SYSTEM TO BE ABOLISHED.

Radical changes in the system of public works construction throughout the Province of British Columbia are foreshadowed in the Public Works Department at Victoria by recent orders coming from the minister, Hon. Dr. King. The road superintendent system will be abolished and the plan which it is said that Hon. Dr. King will bring into effect will mean the appointment of a number of qualified civil engineers, who, with their staffs, will be under the Civil Service Act, and who will each have charge of a section of the province. They will have road foremen for each section. Instead of a road superintendent for each constituency the scheme will mean a road engineer for three or four, or possibly more, ridings. He will be able to do his own engineering work and his road foremen will carry out construction under his direction.

Mr. John A. Traylor, Western Manager of the Traylor Engineering and Manufacturing Co., and the Cement Gun Co., with headquarters at Salt Lake City, Utah, has just opened branch offices for these companies at Spokane, Wash., in charge of Mr. C. H. Adeling, and at El Paso, Tex., in charge of Mr. Robert M. Peabody. The increase in the demand for heavy crushing machinery in the Western territory, and the desire to more thoroughly meet the demand, has made such a step necessary.

In a circular offering a new issue of $1,000,000 first mortgage bonds, George C. Warren, president of Warren Brothers Co., of Boston, states that 41,064,877 sq. yds. of Bitulithic and Warrenite pavements have been laid during the past sixteen years, and 2,233,880 sq. yds. were carried over into 1917. In 1916 there were laid 5,519,765 sq. yds., and there are already in hand orders for 2,584,053 sq. yds. for 1917. "The demand for improved pavements is rapidly increasing, with every indication that the demand will continue for many years to come," says Mr. Warren. The average net earnings of the company for the past five years were $487,626.15, or an average of about $.104 net profit per square yard of pavement laid by the company or by its licensees.

FLUSHING—ITS PLACE IN THE STREET CLEANING FIELD.

By Raymond W. Parlin,
Engineer with the New York Bureau of Municipal Research.

THE various methods of cleaning streets which have been so far developed or which are in the process of development may be classified as: (1) Street sweeping; (2) street washing; (3) vacuum cleaning. Of these three general methods the latter has just begun to emerge in a somewhat imperfect form from the experimental stage. Although vacuum machines are on the market, their value has not as yet been definitely established and this method cannot be considered as being practically available for general adoption.

Fine Dust Problem Forces Changes in Methods.—The extensive use of the automobile has accompanied the great extension of the area of hard surfaced pavements and the increasing demands on the part of the public for clean streets. This high-speed traffic on the smooth street surface has made the fine dust nuisance much worse and more noticeable to the people. The various methods of sweeping both by hand and by machine have, even with the most improved types of sweeping equipment, failed effectively to solve the fine dust problem. Changes in method have been forced upon the officials.

So definite are the needs of the cities for results better than those produced by sweeping that it may be safely prophesied that sweeping in the future will cease to be the primary method of cleaning a modern city and will become an auxiliary to other more efficient methods or used where only rough cleaning is desired.

Sprinkling an Expensive Nuisance.—To reduce the dust nuisance most communities have, prior to the development of satisfactory flushing equipment, systematically sprinkled the street surfaces in the business and many of the residential sections. Sprinkling temporarily sticks fine dust to the pavement. On hot days the effect of this work is so soon lost that numerous repetitions are

Fig. 1.

necessary to prevent the recurrence of dusty conditions. Careless driving of sprinkling carts and poor judgment in the use of water have been common causes of muddy streets or the splashing of pedestrians. Accidents due to the skidding of vehicles on the greasy surface of a wet and dirty street have also occurred.

In general, sprinkling has been considered a necessary evil, but now it can better be termed in all but a few cases an expensive and unnecessary nuisance that should be eliminated by the substitution of a method of cleaning which removes the cause for sprinkling.

Washing vs. Vacuum Cleaning.—The vacuum cleaner presents great possibilities in the removal of fine dust without the use of water. Equipment has already developed which will effectively clean smooth pavements which are in good repair. On rough block streets or wherever depressions exist these machines leave much to be desired. Assuming that entirely satisfactory equipment of the vacuum type is perfected for dry cleaning; and it is believed that such equipment will be developed in the near future, it is questionable whether this type of

Fig. 2.

machine will ever be able effectively to remove mud or wet dust. At present it is obvious that the only practical method available for combatting the fine dust and mud nuisance is some form of pavement washing.

The methods of pavement washing are divided into two main groups: (1) Pavement scrubbing; (2) pavement flushing.

Scrubbing Method Limited to Smooth Pavements.—Pavement scrubbing is almost entirely limited to the use of machine squeegees, although in Europe hand squeegees are used to some extent.

Machine squeegees may be either horse-drawn or automobile-driven. This type of equipment consists of a heavy roller equipped with rubber fins usually attached behind or under a water tank. The roller is rotated against the pavement after the street is heavily sprinkled (either with water from its own tank or from other equipment). It scrubs the surface thoroughly wherever it touches, driving the mud wave or stroke toward the gutter. There the heavy material settles, the water drains off, and it is possible to pick up the dirt from the surface of the street.

This equipment by its very nature is practically limited to smooth pavement in good repair, such as asphalt, asphalt block, wood block and perhaps concrete. On such streets it produces very effective results with a limited use of water.

Motorized squeegee equipment, though in use for a number of years in Europe, has only recently made its appearance in this country.

Flushing Development.—The general adoption of flushing in the last few years is marked. This has been largely due to the introduction of new types of equipment, especially those mounted upon automobile trucks.

Flushing is naturally divided into two classes: (1) Hand flushing equipment; (2) mechanical flushing equipment.

Probably the first flushing of streets in this country was performed at irregular intervals upon restricted areas

by the use of the ordinary garden or fire hose. The development of special hand flushing equipment has, however, mainly taken place contemporaneously with that of mechanical flushing equipment.

Hand Flushing Equipment.—Hand flushing equipment may be divided into two classes: (1) Ordinary hose

Fig. 3.

with nozzle and carrier or reel; (2) special pipe lines and other elaborate equipment.

The latter class may best be illustrated by the Buffalo "portable pipe lines," which are characteristic of many of the special developments which have been used both in this country and abroad. (See Figs. 1, 2, 3 and 4.) This class of equipment, as far as can be learned, has the disadvantages of being awkward to handle (very often requiring the use of more than two men and one or more horses), obstructing streets, and resulting in higher costs than is the case with the best types of hose equipment.

A superior type of hose equipment is represented by the type recently developed for use in New York City. This development is given in some detail as it represents an improvement which may be of use even to the smallest city.

Recent Improvements in Hand Flushing.—Early in 1914 Commissioner John T. Fetherston, of the New York

Fig. 4.

Department of Street Cleaning, found it necessary to improve both the equipment and the procedure used in hand flushing. The commissioner formed a committee among his officers to report on the flushing as then done and to suggest changes. Very few concrete suggestions were secured and it was thought best to make a further investigation. At the commissioner's request the department of water supply, gas and electricity, which has charge of the water system, and the New York Bureau of Municipal Research, an organization independent of the city government, both lent their co-operation; the former with the view to finding some way of reducing what it considered an unnecessary waste of water, and the latter as a part of a program of co-operation with a view to assisting the commissioner to discover and install standard procedure in the department.

Hand flushing was considered at this time to be one of the most important subjects needing study, for several reasons:—

1. It constituted in the minds of the department officers the only satisfactory means which was immediately available for combatting the fine dust and mud nuisance.

2. No money for special equipment of a more expensive nature could be secured and the commissioner wished to do better cleaning.

3. Complaints regarding the methods of performing this work were numerous, especially from the officers of

Fig. 5.

the water department, who felt that great quantities of water were being unnecessarily wasted and who threatened to forbid the continuance of the work.

4. It was believed that by the development of some simple new equipment and better procedure greater economies both in water and in labor could be secured.

5. It was believed that the use of hand-flushing methods would be especially effective in securing a quick clean-up after snow storms, when mechanical equipment would not be satisfactory.

6. It was not certain that mechanical flushing would really be as cheap as hand flushing under New York City conditions.

New York Formerly Used 2½-inch Hose.—Up to the time of the study the department of street cleaning had been using ordinary 2½-inch fire hose and 1¼-inch nozzles. The equipment was carried on the regular sweeper's can carrier or dragged over the pavement from place to place by sweepers. That this equipment was not only ill adapted to the work, but heavy, unsightly and liable to cause rapid deterioration of the hose on account of the sharp bends which were necessary, can easily be imagined after observing Fig. 5, which shows a sample of this old equipment. Investigation indicated that: (1) An average of 1,800 gallons of water was being

used per thousand square yards of pavement cleaned; (2) other cities were using smaller sizes of hose and nozzles with apparent satisfaction; (3) 1½-inch and 2-inch hose and small nozzles would do the work of cleaning properly. Objection was raised to the recommendation that hose as small as 1½-inch be used.

Experiments Lead to Adoption of Two-inch Hose.—Two points of view developed, one looking primarily at the waste of water and the other at the waste of time. It became necessary to run a second set of experiments to determine the size of equipment which would be cheapest to operate from the taxpayers' or general city viewpoint, taking into account both the cost of labor and the cost of water.

This second set of experiments, conducted alternately upon 1½-inch and 2-inch equipment, resulted in the selection of the 2-inch equipment as standard for the city. Attention was at the same time called to the possibility of using the smaller size with equally good results wherever the pressures at the hydrants were in excess of 50 pounds per square inch.

General Principles Established.—As a result of these and further experiments, the following general principles appear to be established:—

1. That the economical size of equipment is dependent upon the hydrant pressures available and the length of hose used.

2. That when the pressure at the nozzle is in excess of 25 pounds per square inch, water is delivered through a ¾-inch or 1-inch nozzle faster than it can be properly used by two men and that it is accompanied by excessive splashing.

3. That when the pressure at the nozzle is less than 18 pounds per square inch, water is not delivered fast enough to keep up with the men nor with force enough to enable them to do effective work.

4. That the smallest size of hose which will give pressures at the nozzle between 18 and 25 pounds is the most economical for use.

5. That better results can be secured by spraying ahead as far as the stream will reach, to give the material

Fig. 6.

on the street a preliminary soaking prior to the direct flushing, than can be secured by the direct flushing of a dry pavement.

6. That larger quantities of water are required to clean rough pavement than smooth, and therefore a slightly larger nozzle may be used to advantage. (It is estimated that a ¾-inch will be satisfactory for asphalt and a 1-inch for rough Belgian block.)

7. That shut-off nozzles are necessary whenever working in traffic, both to save water and to prevent accidents.

8. That where water mains are large enough for

Fig. 7.

proper domestic and fire supply, flushing will not interfere with the ordinary household use.

9. That a hose reel will enable the gangs to do more work with the same expenditure of energy and at the same time lengthen the life of the hose.

10. That by the adoption of procedure which prevents any "back-tracking" of the equipment, over four miles of walking can be saved per gang per eight-hour day in covering a given amount of street, as compared with the procedure commonly used in the past, which saving enables the gangs to do more work.

Equipment and Procedure Improved.—As a result of the studies and conclusions reached, a new hose reel, new hydrant equipment, and improved procedure were adopted by the department and put into effect. (See Figs. 6 and 7.)

The procedure in handling the equipment may be described as starting with the hose reeled so that the nozzle is on top or outside; commencing to unreel when at a distance equal to the length of the hose from the hydrant; unreeling toward the hydrant; placing the reel on the sidewalk near the hydrant; flushing from the point nearest the nozzle past the hydrant and as far as the hose will reach beyond the hydrant; and reeling from the hydrant toward the nozzle; thus completing the area served by a single hydrant. Whenever moving the hose, the "hydrant man" is required to pick it up in loops and drag it ahead in such a way that it will not cross other loops. He is expected to keep a loop at the nozzle end, even with or slightly ahead of the "nozzle man," so that the latter will be free to move without assistance at all times.

Results of New York Studies.—The results of the studies can best be indicated by the illustrations numbered 6 and 7, which show the improved reducer which can be put on the hydrant without the use of a wrench; the improved reel with its tool box, third wheel, and special arrangement for receiving the reducer in winding on the reel; the method of placing the hose along the curb or in the gutter out of the way of traffic; the method of direct flushing; the method of moving the hose from place to place during flushing; the advantage of the shut-off nozzle, and the method of reeling.

The first cost of the equipment is approximately as follows:—

Three 50-foot lengths 2-inch rubber hose at 60c. per foot	$ 90.00
One ¾-inch shut-off nozzle	7.00
One 2½-in. to 2-in. reducer, hand swivel type	2.25
One hydrant key	.15
One hose reel	30.00
	$129.40

(Rubber-covered hose is preferable to cotton-jacket hose for this work.)

THE WORK OF THE ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH IN CANADA.*

By Frank D. Adams, F.R.S.

ONE of the most remarkable and perhaps unexpected results of the great war is that there has been in every country of the English-speaking world a sudden awakening to the importance of scientific research, and a recognition of the necessity of applying it to the whole range of problems which present themselves in both war and peace.

The reason for the awakening is quite a simple one—"The Hun is at the Gate." Great Britain developed as an industrial nation long before Germany had achieved any success in this sphere of effort, and the British system of manufacturing and her industrial expansion was developed by the independent and competitive efforts of a multitude of relatively small enterprises built up on the basis of the artificer and trader and in methods of the olden time. In the last decades, however, Germany having realized her national existence through successful war based on study and good organization, became possessed with the idea that she could become equally successful by the application of similar methods to the more insidious warfare of industry and trade. The note of her success was, as has been said, knowledge and organization, both national in extent. By knowledge obtained through research on a most extended scale and by wise organization of all her powers she proceeded to take from the other nations one after another of the productive industries. From the earliest times woad was cultivated in England. It constituted, we learn from the popular histories of England, in these times a not inconsiderable part of the national dress.

With the opening up of trade with the East, the European dye could not hold its own with the cheaper indigo obtained from the Indian plantations, and these until recently controlled the markets of the world. The German chemist, Adolf von Baeyer, however, in 1880 found that indigo could be made synthetically from toluene. What has been the result? In 1896 India exported indigo of the annual value of over £3,500,000. In 1913 her exports of this dye were worth about £60,000, while the export of indigo from the German factories was valued at about £2,000,000. Moreover, in the above period the price of indigo fell from about 8s. to about 3s. 6d. per pound. Forty or fifty years ago, over the whole of southern Europe and eastward to Asia Minor great tracts of land were devoted to the growing of the madder plant. In France alone 50,000 acres were devoted to its culture. From it was made the bright red dye still known as Turkey red. These madder fields have now all disappeared, for the chemists now make it cheaply, and instead of 750 tons of alizarin extracted from madder roots in 1870, over 2,000 tons are now annually manufactured in chemical works.

The glass industry of Great Britain was stolen away slowly but in a large part. At the outbreak of the war there was being made in England only a couple of dozen kinds of optical glass, while over one thousand were being made by our enemies. It was found, in fact, that the very sighting glasses of the British battleships were made of German glass. Many new industries, such as the production of the great variety of new chemical compounds used for various purposes in industry, arts and medicine, were also built up and secured as complete monopolies by the Germans. The most spectacular case of the transference of an English industry to Germany is afforded by the great aniline dye industry. The method of making these aniline colors was first discovered by an English chemist (Perkins) and the manufacture was actually started in England, but was gradually taken over by the Germans and developed to its present enormous dimensions, yielding annually about £20,000,000 sterling, so that at the outbreak of the war it was found that England was hardly producing one tithe of the various dyes needed for her textile industries which have an annual output valued at £250,000,000.

This successful competition, however, was not confined to such products as those mentioned, for in 1895 Germany passed England in the production of steel, and with this advance came the immense development of the manufacture of iron and of machinery of all kinds and sorts.

This devastating war, the hand-to-hand struggle for the actual right to live, has, however, at length aroused Britain to the realization of the fact that we have reached a new age, and the old cannot compete with the new. Now it is the application of science to industry and the organization of the activities of life that tell—the nation which does not recognize this must fall out of the race. "War," as remarked by Sir Wm. McCormick, "is as much an art as ever, but its instruments, originally the work of the craftsman and artist, are now not only forged by the man of science, they need scientific training for their effective use. This is equally true of the weapons of industry. The brains, even the very processes that to-day are necessary to the output of munitions will be needed to-morrow for the arts of peace."

The government of Great Britain having been brought to a realization of these facts, appointed within less than a year after the declaration of war, a committee of the Privy Council for scientific and industrial research, with an advisory committee composed of eight distinguished men of science and engineering "for the development of scientific and industrial research" applicable to the problems of war and the development of the industries of peace to follow the war. This committee has been at work since that time with very marked success.

The government of Australia followed, establishing a "Commonwealth Institute of Science and Industry" on similar lines. New Zealand and India have also expressed a desire to co-operate with the Imperial Government in any possible way. The United States has engaged in a campaign for "preparedness." No less than three separate organizations have come into existence in that country to this end—the Naval Consulting Board, the National Research Council, which was organized under the authority of the President of the United States of

*From an address before the Canadian Mining Institute on March 7th, 1917.

America, by the National Academy of Science, and the Committee on Scientific Research of the American Association for the Advancement of Science. A good deal of opposition has been offered on the part of certain congressmen to the appointment of any government committees for the purpose of "research" or "investigation," owing to the fact that the only use of the words with which they were familiar suggested something malodorous and reminiscent of muck-raking, accusation and scandal.

Coming to our work in Canada. On June 6th, 1916, a committee of the Privy Council, consisting of the Right Honorable the Minister of Trade and Commerce (chairman), and the Honorable the Ministers of the Interior, Agriculture, Mines, Inland Revenue and Labor, was formed by the Privy Council to take charge of all measures "to further the scientific development of Canadian industries in order that during and after the war they may be in a position to supply all Canadian needs and to extend Canadian trade abroad."

On November 29th, 1916, there was constituted an Honorary and Advisory Council for Scientific and Industrial Research, composed of eleven members representing the scientific, technical and industrial interests of Canada.

(References to the work of the Council have been made in recent issues of *The Canadian Engineer*. See March 1, 1917.)

Among the various subjects to which the Council will address itself in the immediate future may be mentioned the best method of tabulating the natural resources of the Dominion so that all the information which exists concerning them in various government departments and elsewhere may be made readily available. This is a task which it is one of the functions of the government to carry out, and which can only be accomplished satisfactorily by government agencies.

Another very important subject which the Council had under consideration is the best method of gathering about it and associating with its work, committees of gentlemen who have made special studies or who have expert knowledge in certain special industries in any certain definite subjects, and who will be willing to help forward the development of Canada by affording their advice and assistance in their special lines. The Council also has had submitted to it some 44 separate projects. These are already under consideration, or will receive consideration at an early date. Still other proposals have been submitted, while embodying a cheerful optimism and not altogether devoid of humor, will not require such an extended study.

In conclusion, I would remind you that the encouragement of research and the application of science to all our industries and undertakings is a great national work which must be carried forward along many lines and in many ways. The members of the Council will use their best and most strenuous efforts to secure results commensurate with the importance of the work, and they ask you one and all to aid and assist in every way in your power this great work with which the future of our Dominion is so largely bound up.

A rush order for one hundred carloads of lumber, approximating 2,000,000 feet, has been placed with British Columbia mills by the Canadian Government. The Cameron Lumber Co., of Victoria, will supply about ten carloads, and the balance of the order is distributed among all the coast mills which are capable of turning out a few carloads at short order.

PRINCIPLES INVOLVED IN COMPUTING THE DEPRECIATION OF PLANT.*

By F. Gill and W. W. Cook, M.M.I.E.E.

IT is not very satisfactory that engineers should hold such divergent views on so important as question as depreciation. Possibly this is due to the subject being regarded as one for the accountant alone, but in our view depreciation concerns the engineer, the financier, the accountant, and no one of the three is competent to settle the question in any particular case, as, in order to obtain correct results, there must be co-operation between the three.

While this is true in the application of the principles, it is also true that each of the three parties concerned must study the question in all its bearings, and it is just as important that the engineer should understand the financial aspect as it is for the others to follow the engineer's methods in his share of the work.

The depreciation component of cost is very often a dominating one, and it is surely illogical to leave this matter in its present unsatisfactory position while devoting time and money to investigating questions which have far less effect on the total cost.

We can discover no reason why there should not be general agreement on this question; it is so largely a question of fact, and because it is possible to demonstrate the correctness or otherwise of any system, there seems no justification for resorting to mere assertion and appeal to authority in support of any particular theory.

There is no difference of opinion as to the importance of the subject and the necessity for making some provision for depreciation. All plant has a limited life; at the end of its life it is worth nothing, except the value of the material as scrap, and it is clear that, from the moment it is first brought into use to the end of its life, a process of diminution in value is going on continuously.

Although much has been written on this subject, the only points on which all the writers agree are that:—

(*a*) The matter is one of great importance.

(*b*) The term "depreciation" is loosely employed and has various meanings.

A good deal of trouble has been caused by not strictly defining the scope of the subject under discussion, and misunderstandings may be avoided in the present instance if it is made clear at the outset that by the term "depreciation" is intended to be covered: (1) Provision for the diminution in value of plant in place and working (that is, its loss in value to the owner as a continuing plant), by reason of causes *outside* his control, such as age, wear, and accidents; this provision is hereinafter called "renewals." (2) Provision to enable the owner to take plant out of commission before its physical life is exhausted in cases where, from either progress of the art or growth of the business, it is economically advisable to do so (that is, by reason of causes *within* his control); this provision is hereinafter called "improvements."

It should be noted that the expression "renewals" denotes provision in respect of actual expired capital outlay, while the expression "improvements" denotes provision to enable plant to be destroyed while still valuable.

Nothing is further from our minds than any setting up of standard rates of depreciation for all plant or for any sections of plant. There must always be differences

*From a paper read at a meeting of the Institution of Electrical Engineers on January 11th.

in conditions, and it is unlikely that any standard rates can be devised to serve all conditions

While saying this, however, it must be made plain that the principles upon which depreciation is calculated remain fixed, even though the application of those unvarying principles under different conditions produce varying results.

We propose, then, to discuss the principles which govern this question, primarily from the engineer's point of view, and it is hoped that if this be successfully accomplished it will be found to lead naturally to the financier's and the accountant's viewpoints also.

The function of the engineer in this matter is to provide the information necessary regarding the plant, such as first cost, residual value, and life.

The function of the financier is to provide information regarding the money, the amount available, the rate at which it can be borrowed, and the rate that can be obtained for the loan of it.

The function of the accountant is to provide accurate records based on the decisions arrived at, and to see that the real results are neither disguised nor hidden.

All three must come to a common decision, and each in any calculations he has to make must work to it, otherwise nothing but chaos can result.

Generally, depreciation seems to have been regarded as almost entirely an accountant's question, to be brought into discussion only when desiring to ascertain how much of the proceeds resulting from the trading of an undertaking may be appropriated as profits. But depreciation is very important long before this stage is reached, and it is because of the great difference in opinion between engineers themselves, as well as between them and financiers and accountants, that this paper is written, in the hope that some agreement, or at any rate some clear views of the different opinions held, will emerge from the discussion.

Depreciation as Affecting the Design of Plant.—When preparing a specification for plant to achieve certain definite results, there is usually more than one way of arriving at the desired end, and skilful judgment in the selection from among the alternatives must be exercised.

While the first cost* of alternative plans is highly important, in most cases it is nothing like so important as the annual charges, and generally the decision as to which alternative to use can be made upon consideration of the annual charges alone.

One cannot escape the duty of studying these costs in detail by saying that the capital cost and annual charges must be minimum figures; frequently these are mutually contradictory.

It may be advantageous to spend extra capital to obtain low annual charges in respect of one portion of the plant, and deliberately to incur high annual charges by reducing capital expenditure on another portion.

Again, it sometimes happens that even the annual charges of the whole plant will not furnish the desired criterion, since they are not the same for each year, and in those cases they must, of course, be brought to some common time-base.

Annual Charges.—Annual charges are composed of four principal parts:—

(1) Return on capital outlay, treated as a charge, because no engineer, unless in special circumstances, is justified in putting down plant which will not pay a return on its own capital. Even in cases where a return on the outlay is not looked for, the nominal interest is a measure of the burden.

(2) Depreciation—as already defined.

(3) Maintenance, the cost of keeping the plant in as good condition as is desirable, but not of renewing it.

(4) Operation—the cost of working the plant.

The first three enter into the annual charges of all plant; the fourth does not. For example, a boiler or a tram car requires to be operated before it can perform its function, but this does not apply to a pole.

Assume a situation in which there is as yet no plant installed, and let there be two alternative ways of achieving the results required, A and B as below:—

Alternative A—First Cost, £10,000.

Annual charges—Return on capital	£	500
Depreciation		600
Maintenance		500
Operation		900
	£	2,500

Alternative B—First Cost, £15,000.

Annual charges—Return on capital	£	750
Depreciation		450
Maintenance		300
Operation		600
	£	2,100

Annual charges for A = £2,500.
Annual charges for B = £2,100.

It is evident here that, although alternative B requires more capital, it is worth while to expend the greater sum, because the annual charges are less, so that either a reduced sum can be asked for the product, or, since the results achieved are the same, the cash for the product can be the same, and an excess profit made.

At this stage it is desirable to insist upon the importance of the utmost accuracy in the preparation of the annual charges. There is still a great deal to be done in accumulating data regarding these, but so far as is possible they must be accurately founded. When it is remembered that the purpose for which they are required is to enable the engineer by their means to select plant wisely, and so to plan economically, it will be acknowledged that he must use his best endeavors to arrive at annual charges which are as correct in every possible way as he can make them.

If the cost of any plant is to be judged by its annual charges, they must be the true annual charges, and one cannot express these by the single statement that they are, say, 14 per cent. per annum of first cost, unless either the cost is uniform each year, or the rate mentioned is an equated rate taken over the prospective life of the plant.

With reference to uniformity:—

Return on Capital.—The amount will be uniform if the capital has not been written down—that is, if the sums put aside for depreciation are kept in a separate fund until the sum that is required has been accumulated. If, on the other hand, part of the capital is paid off each year, the sum for return will decrease each year.

Depreciation.—Here, again, the amount required will vary according to the method of making provision and to the treatment of the capital account.

Maintenance.—For the present, let it be assumed that this is constant each year. This point will be returned to later.

*The expression "first cost" is intended to mean any or all of the following as the context requires: (*a*) the original construction cost; (*b*) the estimated original construction cost; (*c*) the estimated construction cost to reproduce the plant new.

Operation.—This is also taken as constant.

It is seen, then, that the sums required for return on capital and depreciation both depend upon the treatment of the capital account and the depreciation fund; in fact, these two are so intimately connected that their costs cannot be treated independently.

Lives, Physical and Economic.—For the purpose of this paper there are two lives which must be defined:—

(*a*) Physical life—that is, the period during which the plant would continue to perform satisfactorily the service to which it is adapted, if allowed to do so, but subject to all causes *outside* the control of the owner, such as wear and tear or accidents.

(*b*) Economic life—that is, the period of physical life shortened by causes *within* the owner's control, such as desire for economy, improvement of service, the taking out of plant because a greater capacity is required.

It is necessary to distinguish quite clearly between these two. The physical life affects the amount to be put aside each year for renewals, and, since by definition the plant can perform its service satisfactorily during the whole time, there is no compulsion to renew before the conclusion of the physical life.

The renewals fund thus ensures that the money invested in plant is always represented by the assets, provided that none of it is voluntarily destroyed.

In the conduct of a business, however, it is often desirable, in the interests of shareholders and consumers alike, to take plant out of commission before the end of its physical life, either because more economical plant is available or because it is no longer capable of meeting new developments of the business.

Since the main cause for these changes is economy, it may be argued that the cost of making them should be defrayed by new capital; but this is not always available, and if this course were adopted the new capital would not be represented by assets until the new plant had earned enough extra profit to pay for the wastage.

In order that the owner of the plant may be always in a position to take advantage of developments, and still be in a sound position, it is necessary to have a special fund available for the purpose, and such a fund is referred to in this paper as the improvements fund.

As such a fund is necessary for the successful conduct and progress of the business, the annual contributions are, in a continuing business, part of the annual charges against the plant.

The distinction between the renewals fund and the improvements fund must constantly be borne in mind.

The charges to the renewals fund represent actual expired capital outlay each year, and consequently are the measure of the diminution of the value of the plant in place considered as a structure, while the improvements fund enables plant to be superseded before its physical life is ended, and ensures that when this is done the value of the assets shall always represent the invested capital.

In a change of ownership where it is a condition that the purchaser should take over the plant as a structure, and the valuation is to be on the basis of physical life, any balance which stands to the credit of the improvements fund represents a reserve out of profits which has not been required and belongs to the seller, but if the business is purchased as a going concern, the desirability of superseding plant in the near future may be one of the factors determining the price, in which case it will be necessary to bring the improvements fund into account.

Method of Arriving at Provision for Renewals and Improvements.—Looking first at renewals, what change has occurred in plant which causes it to diminish in value from 100 per cent. when it is new to, say, 10 per cent. at the end of its physical life?

If one takes one of the simplest possible structures, a creosoted telephone pole, and examines it, say, five years after erection, one cannot say positively that either its weight or strength is less, as there is no perceptible decay in most cases, nor can one say that it is earning less, as it will frequently be earning a larger sum per annum than at first because carrying more wires.

In fact, the only solid ground for saying its value has decreased is that it is five years nearer to the end of its life, and the question is how to find the diminution in value caused by the passage of these five years.

The methods of arriving at the deduction to be made for any plant which has already been in existence some time may be divided into two classes:—

(*a*) Based on a detailed examination of the plant and an individual assessment of values for each item.

(*b*) Based on an estimated life which the various classes of plant will have under a given standard of maintenance, and providing for the diminution in value by writing off or setting aside a proper sum in respect of each expired year (or other portion) of life.

When carefully examined, there is really no sharp dividing line between these two methods.

In the case of detailed examination (*a*), proper weight can be given to condition, but physical examination alone will not enable a proper deduction to be made for the depreciated state of the plant. In some cases, for some years, the plant shows no sign of wear or decay, yet obviously some provision ought to be made for the expired life during these years.

It is usual, therefore, and necessary, to estimate the first cost, life, age, and residual value.

If individual items of plant are dealt with, the life and some times the age can only be judged very approximately.

If, as in method (*b*), the bulk is considered instead of the individual items, the life and age can be estimated with much greater certainty, while consideration of the amount spent on repairs and upkeep, supplemented by inspection, will give the condition.

While expert examination has a proper and most useful sphere in all cases, and is almost essential in determining the economic life, there is no means whereby one can examine plant and by that examination alone estimate what is the value remaining in the plant in place; some method of computation must be adopted.

The measurement of the effects of wear and tear and the passage of time is essentially a financial operation, and no satisfactory solution can be found without going through the steps of establishing the first cost, residual value, life, and age.

It is often said that one cannot say how long a certain plant will last; but this is not a sufficient answer. One must estimate the life if there is to be any attempt towards scientific treatment in planning.

One cannot neglect capital charges—*i.e.*, return on capital and provision for depreciation; and the latter depends very largely upon life.

Those who say the life cannot be estimated, and take, say, 10 per cent. as capital charges, do, in fact, estimate the life, though they do not state the period, and they do so without taking the necessary precautions to estimate it correctly, because for any particular rate of return on money and with a given residual value, 10 per cent. per annum can only be arrived at by one definite life.

LEAKAGE FROM PIPE JOINTS.*

By F. A. Barbour, Consulting Engineer, Boston.

ON September 7, 1915,—as a result of a paper read by Mr. Arthur H. Smith before this Association, a committee was appointed "to investigate experience in the leakage of pipe joints."

The present brief statement is not a progress report from the committee; rather it is made for the purpose of inducing a more active interest in the investigation by the members of the Association, and particularly with the hope that a discussion may result which will be of value in the further work of the committee. Any opinions expressed are the personal views of the writer and not of the committee.

As the best method of obtaining the results of experience in joint leakage, a circular containing 37 questions was mailed to 430 members of this Association, and to 124 members of the American Waterworks Association. From the 554 circulars sent out, 131 replies have thus far been received, 46 of these being from the members of the American Water Works Association. Only 85 replies were received from the 430 circulars sent to the members of the New England Water Works Association. When only one in five members takes any notice of such a circular it is evident that either the subject of the investigation is of little moment, or else the members do not appreciate the value of co-operation if any results of value are to be obtained.

It may be—and in regard to this it is hoped that members will to-day express their opinions—that leakage from pipe joints is not generally an important factor, and that the present type of joints driven and tested, or not tested, as may be the practice, is entirely satisfactory. It also may be, and probably is true, that such leakage from mains as does occur is not general, but is rather located in a few imperfectly made joints; or, in other words, that the average present standard design and workmanship is good enough. While this may be true, it comprehends the subject chosen for investigation, and thus far little information of definite value in reaching any conclusion has been received by the committee.

One fact, however, stands out, namely, that even in the fully metered systems, about 20 per cent. of the total water supply is unaccounted for by sale to the consumers. Thus, of the 131 replies received, 10 per cent. report the services to be entirely metered and 30 per cent. more than 85 per cent. metered, and the average water unaccounted for, as estimated in these systems, is 21 per cent. This loss is chargeable to leakage from mains or services, or to failure of the meters to register. It would seem to be worth while attempting to locate the cause of a 20 per cent. loss of the water furnished. If slippage of meters is the explanation, this simply means that consumers are getting more than they are nominally paying for, but, if leakage from the mains and services is responsible, the result is an absolute loss of water which costs money to develop and deliver to the distribution system.

The average consumption in the 40 systems in which 85 per cent. or more of the services are metered is, as reported, 68 gallons per day per capita. The average estimated unaccounted-for water was, therefore, equivalent to about 14 gallons per day per capita, or a loss of 5,000 gallons per year per capita, which, if the cost is estimated at $25 per million gallons of water delivered to the distribution system, is equivalent to a yearly cost per capita of 12½ cents, or approximately the interest on $2; in other words, a town of 10,000 people could afford to expend $20,000 in order to prevent this loss of 14 gallons per day per person.

If, then, in these fully metered systems, which undoubtedly represent the best condition, only 80 per cent. of the water supplied is sold to the consumers, the question arises as to whether this should be accepted as the highest standard of efficiency which can be reasonably attempted.

If, in any considerable part, the unaccounted-for water is chargeable to slippage of meters, then it would seem desirable that increased attention should be given to the subject of maintained accuracy and sensitiveness of meters.

If meter slippage is not the explanation of the unaccounted-for water, then the loss must be through leakage from the mains or services.

As to the loss from services, 80 per cent. of those replying to the circular estimate this to be small or none. As to the leakage from mains, 99 of the 131 answers received do not attempt to estimate this loss; 18 state it to be very small or none; and 14 estimate it in percentage of the total amount supplied, the average of these few figures being 15 per cent.

From the replies already received, therefore,—and these presumably are from those departments best able to answer the several questions, or most interested in the problem,—it is evident that, while undoubtedly a considerable portion of the water supplied is not sold to the consumer, there is little or no definite knowledge of the actual conditions of the pipe joints. The general impression, as indicated, is that the mains are fairly tight and that the leakage from services is small. It may also be inferred, from various notes in the replies received, that such leakage as may occur in mains is located at certain isolated joints and is not general.

One phase of the investigation as conceived by the committee was that in reference to the practice of testing pipes when laid. Believing that in the majority of cases local conditions would not permit the trenches to be kept open until the pipes were tested, the question was asked as to the reasonable allowable leakage in testing after backfilling, as determined by the measured water necessarily introduced to maintain the test pressure. Such a method of testing is, of course, not to be compared with the visual examination of the joints under pressure, but it is necessary in many cases.

Of the 131 replies received in reference to testing pipe when laid, 76 state such tests are made, 36 that no tests are attempted, and 19 that sometimes the pipes are tested and sometimes not. The interesting and rather surprising feature in these replies is that all but six of those who state that the pipe is tested report that the test is made before backfilling the trench. Further, of the 75 who replied to the question as to the standard of tightness required before putting the pipe in service, 63 state this requirement to be "absolute tightness." Of those who report that it is customary to test the pipe when laid, 85 per cent. state that the test is made under the working pressure which the pipe is to carry in service. Only 18 report tests in excess of working pressure, the test pressures ranging from 30 lbs. excess to double the working pressure.

From the information received to date, it therefore appears that it is quite the general practice to test before backfilling and to require absolute tightness under the working pressure. If these replies can be accepted as

*Journal of the New England Water Works Association.

expressing the general practice of water departments, it is evident that the present standard is high, and the only question which might profitably be asked is as to what happens to the joints when the higher pressures due to water ram, and more or less incident to the operation of every system, are applied, and whether, therefore, pipes should not be tested at some pressure above that of working conditions. It is noticeable that but very few of the statements made in reference to leakage from mains and services are based on any actual tests after the pipes have been in use for any period of time, and the opinions expressed are generally formed from observation of such joints as have from time to time been exposed. Only four definite statements of tests for leakage of pipe after periods of use are reported, and these indicate only a small loss from the joints.

Naturally, only those systems where a high percentage of the services are metered can make any accurate estimate of the water not delivered to consumers. Where less than 75 per cent. of the services are metered, waste by carelessness inside the premises of consumers is undoubtedly the great factor in determining the amount of water supplied—a condition which clearly stands out in the replies received, by comparing the water furnished per capita with the per cent. of metered services. Thus, with due allowance for special industrial demands, the relation between meters and amount supplied is very approximately as follows:—

100	per cent.	metered,	68	gallons	per day	per capita.
75	"	"	75	"	"	"
50	"	"	90	"	"	"
25	"	"	110	"	"	"
0	"	"	125	"	"	"

It is therefore evident, as would be expected, without the evidence of the present investigation, that, in the conservation of our water supplies, metering of the services is the great factor, and leakage from mains, except in particular instances, is of minor importance.

While this is true, however, there remains the fact that in completely metered systems the average unaccounted-for water amounts to about 20 per cent. of the total amount of water delivered to the distribution pipes.

Whether it is economically possible to reduce this loss by a better type of joint, better workmanship, testing at pressures above normal, cannot be determined by the evidence thus far made available to the committee. The information most needed to reach conclusions is that giving the results of leakage surveys of actual tests made after the pipes have been in service some years, of experimental work showing the relation between pressure on the joints and leakage, and, particularly, data from those departments where accurate tests have shown leakage in mains to exist. There is no doubt that in many cases there is a large loss from the pipe system, even though in the replies received to date to the circulars of the committee the great majority regard this loss as very small, or refuse to make any estimate.

The object of this brief preliminary consideration of the subject is to ask that members who have not replied to the circular do so at once, and particularly that any member who has at hand the results of definite leakage tests submit such information, which will, of course, be considered confidential.

An expression of the opinion of members on the general question as to whether further investigation of joint leakage is worth while would be of considerable interest.

CHARTS FOR ECCENTRIC LOADING ON RECTANGULAR AREAS.

By S. M. Cotten,
Bridge Engineering Department, Kansas City Terminal Railway, Kansas City, Mo.

THE charts presented herewith give a graphical solution of the foundation-pressure formula $s = \frac{P}{L}\left(1 \pm \frac{6e}{L}\right)$. As usual, s is the pressure per square unit, P the vertical load on the foundation per unit of width, L the length of foundation, and e the eccentricity of P about the centre of the foundation. The same units should be employed for L and e, either inches or feet, so that, if P be expressed in pounds, s is given in pounds per square inch or per square foot respectively.

The charts will cover any probable requirements of practice, but their scope may be infinitely broadened by remembering that it is entirely immaterial what units are used to express e, L, s and P, provided only that these are expressed in corresponding terms. For instance, if, when using the inch as the unit, a value of L greater than 60 is required, transform the given quantities into feet and pounds per square foot, which will give a value of L covered by the charts.

Since the function k given by the charts is the value of the maximum pressure, s_1, when $P = 1$, Pk will give the value of s_1 for any other value of P.

Use of the Charts.—Given P, L and e, to determine the maximum and minimum pressures, s_1 and s_2. From the value of e, shown at the bottom of the chart, trace vertically up to an intersection with the line representing the given L; thence horizontally to the left, and read the value of k. Then, $s_1 = Pk$, $s_2 = 2\frac{P}{L} - Pk$. The value $2\frac{P}{L}$ can be read off at once, as it is $2Pk$ for $e = 0$.

Given P, e and desired value of s_1, to find the required length. Since $Pk = s_1$, $k = \frac{s_1}{P}$. Compute the value of k; enter the chart with this and trace horizontally to an intersection with the vertical representing the value of e; the required length lies on this intersection.

Given L, e, s_1, to find the maximum permissible load, P. Enter the chart with the value of e; trace vertically upward to an intersection with L; thence horizontally and read the value of k. Since $s_1 = Pk$, $P = \frac{s_1}{k}$.

The accuracy of the charts, to the extent indicated by the scales chosen, is assured by the fact that three values were computed and plotted for each value of L, the straight line representing this passing through all three points.

A few auxiliary facts that most texts appear to neglect may be worthy of mention.

To interpret properly the equation $s = \frac{P}{L}\left(1 \pm \frac{6e}{L}\right)$, it must be understood that this is merely a special form of the equation $s = \frac{P}{A} \pm \frac{Mc}{I}$, in which P is the normal load; A, the area to which P is applied; M the moment of P about the centre of gravity of A; c the distance from the centre of gravity to an edge of A; and I the moment of inertia of A about its centre of gravity. When A is a rectangle, the latter equation reduces to the former.

If the distance d of the load from one end of the foundation is fixed, an investigation of the charts will

show that s_1 is a minimum (and hence P, the supporting power of the foundation, is a maximum) when $L = 2d$. The variations in s_1 and P for $d = 6$ and various values of L are shown in Table 1. It will be observed that the values of s_1 and P increase and decrease respectively as L increases from 12 ($= 2d$) to 18, at which point the order is reversed. For $L = 18$, $e = L/6$ and $s_2 = 0$; hence for values of L greater than 18, s_2 is negative, giving tension in the heel. The formula assumes that this tension is an actual force or stress, as the tension area of a section of a loaded beam. Consequently, in the case of foundations, unless an equivalent tensile force is provided, as by means of anchor bolts, the values given by the formula, or the charts, for values of e greater than $L/6$ are not true. If the conditions are such that tensile stresses are not provided for, the maximum length, L', over which P may be distributed, is $3d$. Hence, when d is less than $\frac{1}{3}L$ (e greater than $\frac{1}{6}L$), $s_1 = 2P/L'$, and $s_2 = 0$. Of course, this consideration does not ordinarily enter into foundation design, it being an established principle that the resultant shall not cut the base outside the outer edge of the middle third.

Table 1.—Fixed Edge Distance of Load.

Showing variations in s_1 and P as L varies, the distance of the load from one end of the foundation being constant and equal to 6.

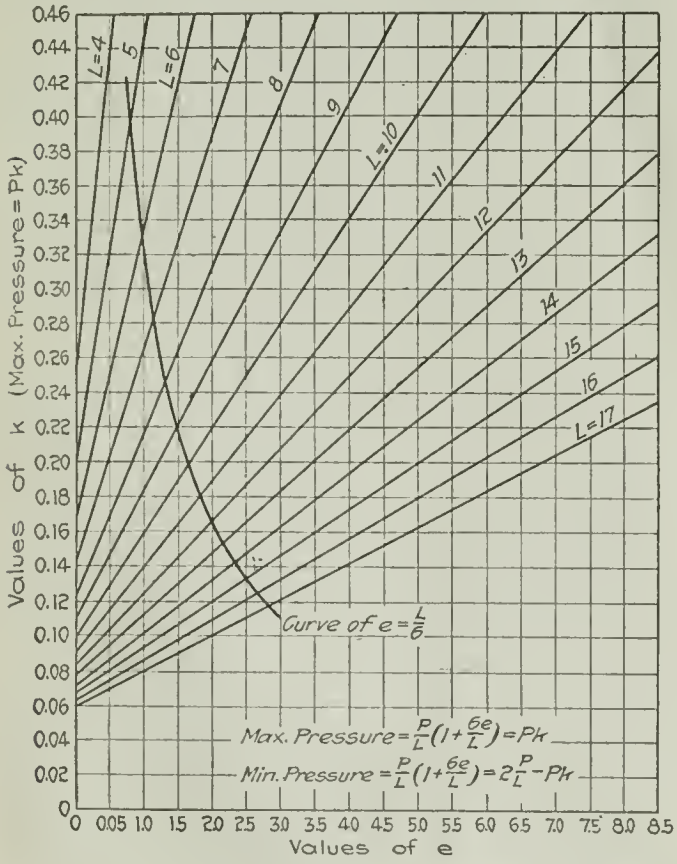
Values of L.	Values of s_1 when $P = 1$.	Values of P when $s_1 = 1$.
7	0.448	2.2
8	0.312	3.2
9	0.220	4.6
10	0.160	6.2
11	0.115	8.7
12	0.083	12.0
13	0.094	10.6
14	0.102	9.8
15	0.107	9.3
16	0.110	9.1
17	0.111	9.0
18	0.111	9.0
20	0.110	9.1
22	0.107	9.3
24	0.104	9.6
26	0.101	9.9
28	0.097	10.3
30	0.093	10.7

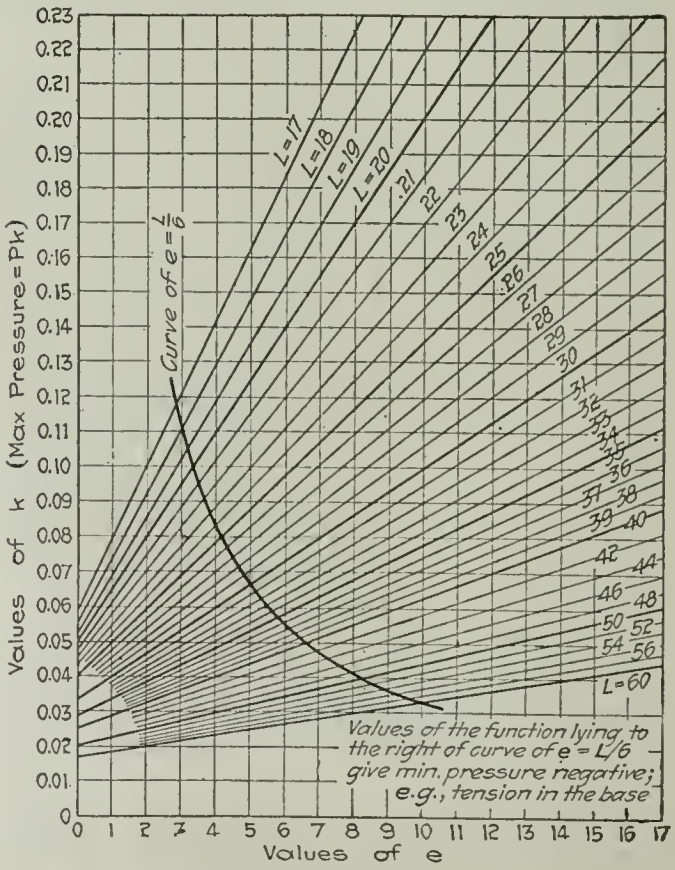
Table 2.—Variation of Proportions of the Footing.

Showing proportional carrying power of an area of 24, Eccentricity of load of 3, as L and the width b vary.

Values of L	Values of k	Values of P when $s_1 = 1$	Values of b	Values of Pb
24	0.073	13.70	1.0	13.7
20	0.095	10.54	1.2	12.6
16	0.134	7.47	1.5	11.2
12	0.208	4.81	2.0	9.6
8	0.406	2.46	3.0	7.4

A case that sometimes arises is: Given the vertical load and its eccentricity, to determine the most economical dimensions of the footing. The charts will show that the area required decreases as L increases. Table 2 shows a special case of the relative bearing power of the same area, for a fixed value of e, as L varies. Though a specific case, the conclusions therefrom are general; namely, that the minimum area to carry a given eccentric load will be given by making the length of footing as large as possible. —"Engineering News," New York.





Diagrams for Pressures on Eccentric Loadings.

Editorial

MUNICIPAL CONSULTING ENGINEERS.

O. J. Godfrey, F.C.A., past president of the Dominion Association of Chartered Accountants, has contributed an article to a western municipal journal, in which he makes a direct and unjustified attack upon the engineering profession. To sum up his charges, he alleges:—

(1) That municipal consulting engineers purposely underestimate the cost of improvements so as to obtain the voters' consent to the projects;

(2) That the over-expenditures would not occur if the engineers did not get a percentage on the over-expenditures;

(3) That he knows of no case where the actual cost of waterworks or electric light came within the original estimate made by the consulting engineers.

Of course, Mr. Godfrey's charges were not quite so bluntly worded, but when stripped of their excess verbiage, they are in fact exactly as above stated. As a remedy he suggests that a board of engineers be organized by the province (his argument deals principally with conditions in his home province of Saskatchewan), the board's services to be placed at the disposal of all towns and cities in the province. The provincial officials are subsequently to fix the amounts to be paid by the municipalities to the province for any services rendered by the board.

Mr. Godfrey's three charges are hardly likely to be taken seriously by any municipal official who has the slightest knowledge of the ethics and standards of the engineering or any other profession. To engineers themselves the charges are mildly amusing. They are on a par with some other ideas prevalent among some very narrow-minded laymen, such as that surgeons operate unnecessarily for the fees derived; that lawyers drag cases through pre-arranged red tape in order to increase the legal costs; and that dental surgeons drill holes in perfectly good teeth in order to create something to fill.

Any number of cases can be cited where the costs of finished engineering work have been within preliminary estimates. And frequently it is not the engineer's fault when estimates are exceeded. Additions to the original work contemplated, failure of councils to provide the necessary funds when needed, depreciation due to mismanaged sales of debentures, change in sites, increase in prices of materials while council is "getting together" on the proposition, and many other factors beyond the engineer's control often result in excess expenditures.

Any engineer who would indulge in sharp practice such as alleged by Mr. Godfrey, would be disciplined unmercifully by his fellow-engineers. It is not likely that Mr. Godfrey can quote chapter and verse in substantiating his sweeping but vague charges, but if he can, the Canadian Society of Civil Engineers would no doubt be glad to take prompt action upon any real facts that he is able to produce.

Failing the ill, no remedy is needed. But even if such evils did exist, Mr. Godfrey's proposed remedy is unsound. Socialistic action such as suggested by Mr. Godfrey generally results in monopoly, despotism, inefficiency and loss of personal enterprise. This sort of community municipal engineering service has been tried before, not a thousand miles from where these lines are penned, with results that apparently do not outshine individual effort, taking the whole facts of the cases into consideration, and carefully weighing them in the balance.

THE WAR LOAN.

Aside from the patriotic phase, the Canadian war bond is an excellent investment. Dominion government bonds, in point of merit, rank ahead of all other Canadian issues. Our credit in the United States is better even than that of Great Britain. No one in Canada or, for that matter, anywhere else, doubts the stability of the borrower. Canada will be able to meet the interest on its war loans, past, present and future, without any difficulty. Our shores are free from the invader and, thanks to the British navy, are likely to be. While the Dominion is prosecuting its share of the war vigorously, those who are staying at home are seeing that greater production is achieved from the soil and from natural resources.

However pessimistic the passing phases of the Great War may be inclined occasionally to make us, no one who analyzes the available facts, can doubt ultimate victory or fail to have well-seasoned optimism in the future of this Dominion, of the British Empire and of their securities.

Small subscriptions are an important factor in the success of our war financing. The outstanding feature of the recent British "victory" war loan was the great number of small subscriptions, which helped to swell the loan to record proportions. Our banks have much to do in financing war orders placed here and in carrying the increasing volume of agricultural and industrial production. Financial and other corporations will subscribe liberally to the coming war loan, but it is absolutely necessary that many thousands of subscriptions, ranging from $100 to $25,000, should be received in order to make the loan a real success. Dominion war loan bonds are one of the world's best investments and have a patriotic flavor. A subscription to our war loans is not a sacrifice. It is a duty, and incidentally it remunerates the subscriber handsomely.

A large number of small subscriptions to the war loan will be more appreciated by the government than a small number of large subscriptions. The allotment of the loan to large subscribers will be cut down by the government so that all the small subscribers may have their full share of bonds.

There are many thousands of people who have from $100 to $5,000 for investment. Their duty is to lend this money to their country. The security of the war bond is excellent, the income yield is high and the bonds are readily saleable at any time, should the holder desire to sell.

INVESTIGATION OF THE HYDRO RADIAL PROJECT AT HAMILTON.

In last week's issue reference was made to the investigation being made into the Hydro Radial project at Hamilton and to the appointment of a board of five engineers who had been asked to submit a report thereon. In the same item reference was made to the Canadian Northern-Hydro-Electric controversy.

In order to remove any misunderstanding which may have been caused by the publication of this item it is only proper to state that this board of five engineers, consisting of Messrs. Leonard, Kennedy, Tye, Herdt and Francis, was appointed specifically to report as to the need of a proposed Hydro-Electric line from Port Credit to St. Catharines, Ont.

It will be remembered that when the by-law in connection with this road was submitted to the ratepayers of Hamilton on January 1st last, the said ratepayers refused to authorize their council to enter into the proposed agreement with the Hydro-Electric Power Commission for the construction and operation of such a line. It having been intimated that the rejected by-law would again be submitted at an early date, a citizens' committee, of which C. W. Cartwright is chairman, wrote to the Toronto Branch of the Canadian Society of Civil Engineers asking that it name five engineers who could investigate the radial proposition and submit a report which would enable the citizens of Hamilton to determine whether the project was in the public interest or not.

As a result of this communication to the Toronto Branch of the Canadian Society of Civil Engineers, the board of engineers already referred to was appointed.

Its investigation is to be confined to the proposed Hydro-Electric line from Port Credit to St. Catharines with special reference to the interests of Hamilton in connection with it.

PERSONAL.

G. M. CAREY has been appointed a member of the Hydro Commission of Petrolia, Ont.

W. VALLANCE, assistant municipal engineer of Point Grey, B.C., has resigned.

E. J. ZAVITZ, formerly on the staff of the O.A.C., Guelph, has been appointed provincial forester for Ontario.

JOHN R. McDONALD, who has for several years been in charge of the mines of the Franco-Canadian collieries, at Frank, B.C., has resigned.

F. A. DALLYN, A.M.Can.Soc.C.E., provincial sanitary engineer, Toronto, has returned from England, where he has been investigating sewerage and sewage disposal plants.

SAMUEL D. WILLIAMS, for the past three years chief division civil engineer of the M.C.R. at St. Thomas, Ont., will leave shortly to take up new duties in the Detroit office of the company.

D. WALTER MUNN, of the Montreal Rolling Mills branch of the Steel Company of Canada, has joined the engineering department of the Algoma Steel Corporation, Sault Ste. Marie, Ont.

E. W. DuVAL, formerly superintendent of the C.P.R. at Saskatoon and Moose Jaw, has qualified for the rank of lieutenant and has been appointed O.C. of the University draft for the 196th Western Universities Battalion.

SAM R. HENDERSON, for seven years president of the Manitoba Good Roads Association, was presented with a heavily jewelled and suitably engraved gold watch at the recent annual banquet of the association in recognition of his record of valuable service.

WILLIAM HENDERSON, who has been resident architect of the department of public works, British Columbia, for the last fifty years, was presented with an illuminated address and a gold-mounted ebony cane at a banquet recently held in his honor at the Dominion Hotel, Victoria, B.C.

Lieut. G. ROY COCKBURN, formerly a professor in the University of Toronto, who went overseas with a draft of officers from the 170th Mississauga Battalion and was attached to the 58th Battalion in France, has now been transferred to No. 2 Field Survey Co. of the Royal Engineers. This unit is officered by scientists drawn from universities of the Empire.

H. B. HAWKINS, of Brantford, Ont., who has for the last six months been assistant to E. E. Curtis, manager of the Brantford Gas Company, has been advanced to the managership in place of Mr. Curtis, who has left for Bartleville, Oklahoma, where he takes the position of inside manager for the H. L. Doherty Company, which controls the Brantford office.

M. A. GRAINGER, who has been acting chief forester for the province of British Columbia since H. R. MacMillan's appointment as lumber commissioner to study foreign markets, has now been appointed chief forester. Mr. Grainger, who is a graduate of King's College, Cambridge, England, came to Canada in 1897. He joined the Forestry Branch upon its inauguration and has occupied an important position in it ever since.

OBITUARY.

DENIS MURPHY, former M.P.P., and a member of the Timiskaming & Northern Ontario Railway Commission, passed away at his home in Ottawa on March 10th. The deceased had been in failing health for the past six months, and his death was not unexpected. He was in his 75th year, having been born in the county of Cork, Ireland, on April 2nd, 1842. In 1849 he came to Canada with his father and settled in Chatham, P.Q. For a long time he was engaged in the forwarding business on the Ottawa River, in partnership with the late J. W. McRae, and in 1892 he was elected president of the Ottawa Transportation Company, which office he held until his death. Since 1905 he had held the position of government commissioner for the Timiskaming & Northern Ontario Railway.

THOMAS BROOKE TOWNSEND, of Aldershot, Ont., passed away recently. Deceased was born in Yorkshire, England, in 1834, and came to Canada in 1857. He was a civil engineer by profession, and was associated for many years with the old Great Western Railway. He had charge of the rebuilding of the bridge over the Desjardins Canal that replaced the structure destroyed in the great Desjardins Canal accident. In 1860 he designed and supervised the building of the private car used by the late King Edward on his tour of Canada. In 1872 he entered the service of the Department of Railways and Canals, and he designed the Welland Canal locks, gates and bridges. In 1881 he retired from the Department of Railways and Canals, and a few years later retired from active work and took up farming at Aldershot.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

SOME PROBLEMS OF THE WATERWORKS EXECUTIVE*

ADMINISTRATIVE SYSTEM APPLIED TO DISTRIBUTION, SERVICE CONNECTIONS, FIRE SUPPLIES, METERS AND ACCOUNTS

By GARRETT O. HOUSE

General Superintendent, Bureau of Water, St. Paul, Minn.

THE waterworks executive is expected to administer the affairs of his office efficiently, and, inasmuch as the efficiency equation involves the proper way to do work, and also the way work is performed, he must be qualified to know how the different divisions of his department should be conducted, how individual work should be performed, and he must also know how the actual work is conducted and how much is accomplished. The ideal of the waterworks executive is furnishing an adequate amount of pure and wholesome water for all purposes to all citizens indiscriminately, under reasonable conditions and at reasonable rates. This is the main problem, and its fulfilment involves many lesser problems.

In order to bring out the problems of the waterworks executive, I will, because of my intimate knowledge and connection with the bureau of water in St. Paul, analyze the organization chart of the water department of the city of St. Paul. As will be noted on the accompanying graphic representation of our organization, the commission form of charter under which the municipality of St. Paul is governed provides that the affairs of the water department shall be administered through an elective board of water commissioners, of whom the commissioner of public utilities is president, and the commissioners of public works and of finance are members. The charter provides that the commissioner of public utilities shall administer, as president of the board of water commissioners, all of the general business of the water department; that the commissioner of public works shall have charge of all engineering and construction; and the commissioner of finance shall collect all revenues. The charter also provides for a central purchasing agent, who purchases all supplies and material used by the water department; also that the comptroller shall prescribe the method of accounting and audit all accounts of the water department. He also, as civil service commissioner, certifies to the eligibility of all employees, and also audits all payrolls. From this it is evident that the activities of the water department are, by charter provision, placed in the hands of many individuals. Since all of these activities are dependent and interlock one with the other, it was deemed necessary and advisable for each of the elective officials to deputize one person to administer, under their direction, the authority which the charter has vested in them. To this person has been given the title of general superintendent and he becomes the executive of the water department.

A waterworks, as a rule, is a monopoly, and the opportunity is given to make unreasonable rules, decidedly in favor of the company or department. Water is a necessity, and no commodity contributes so much to the health and prosperity of a community as water, therefore the service should be within the reach of all.

Under this same general heading may be considered rates, which, however, are determined not upon theory but from actual facts. The waterworks executive, having made the rules and regulations and rates under which the department is to be operated, now turns his attention to perfecting an organization through which all the various activities of the department may be carried on, and the rules and regulations laid down may be carried out.

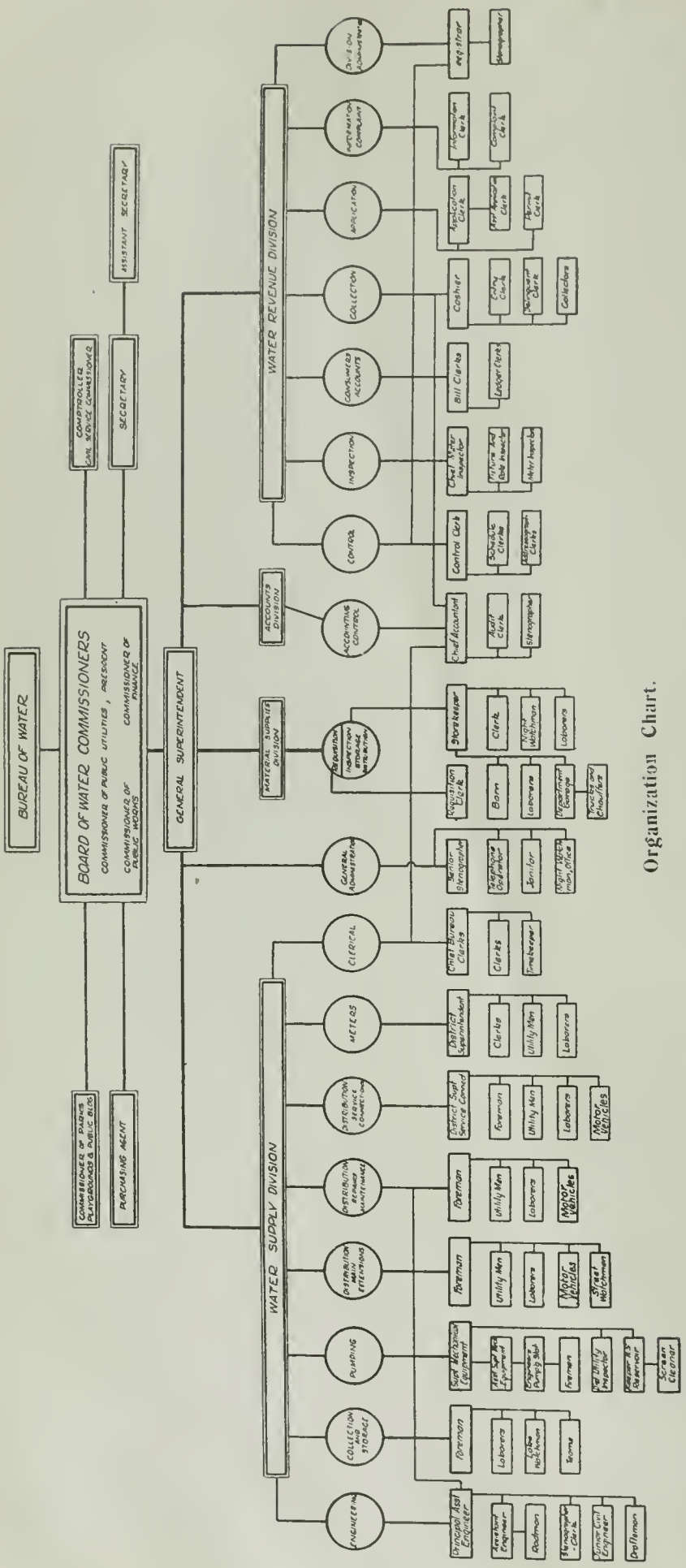
You will note that the organization of the water department of the city of St. Paul is divided into four separate divisions: water supply division, water revenue division, accounts division, and materials and supplies division. Let us consider, therefore, first, what problems, if any, are to be found under the heading, "Distribution, main extensions." How should extensions be made in the newly developed portions of the city? In St. Paul, one general rule is followed. If the street upon which the extension is asked is graded to the grade established by the city engineer, and if there is a reasonable demand for water on this street, a petition for main extension is usually granted by the board.

An engineering problem of great importance is also involved in the matter of extension of mains, particularly in a rapidly growing city, concerning which time will not permit a discussion in this paper. The location of the water main in the public street at any other point than at the centre involves a greater expense to owners on one side of the street than the other in making a service connection.

The problem of taking care of repairs and maintenance of water mains and appurtenances must, I think, be worked out in each individual case, because conditions vary in almost every city. One thing, however, is certain, that the selection of men to perform this class of work must be in every sense emergency men.

Under the next sub-division, "Distribution, service connections," many problems are involved, including the materials of which service connections are to be made, the method of installing them, whether by the water department or a licensed plumber in the service of the owner of the property to be served, the size permitted, and the location of the control fittings. In St. Paul extra strong lead pipe is used for all service connections up to and including 1½-inch; for 2-inch, galvanized iron pipe is used, and for larger service connections, cast iron. All services are laid by the water department. Not only is there a question of who should lay the water service connection in the street, but there is also the question

*Abstract of paper read before the Minnesota Section of the American Water Works Association.



Organization Chart.

of who should maintain it. In St. Paul, at present, it is laid by the water department at the expense of the owner of the property and thereafter maintained by the water department, also at the expense of the owner of the property.

In this division we also have the problem which, as yet, remains unsolved, service connections to private fire supplies. This has been a subject of much discussion in engineering and waterworks societies, and there is a decided difference of opinion. It is a most important problem, and I believe should be solved by accepting a procedure midway between the theory of the National Board of Fire Underwriters and the practice of some waterworks engineers and executives.

It seems to me that the provisions of the National Board of Fire Underwriters with respect to the size of service connection necessary for supplying automatic sprinkler equipment is in many cases entirely too liberal and does not take into consideration the elements which must enter into a determination of water supply. The board of fire underwriters requires, for instance, that a 6 inch service connection must be supplied for sprinkler equipment located in one fire area in excess of 85 sprinkler heads. No consideration is given the matter of pressure, and notwithstanding the fact the National Board indicates that one sprinkler head will reasonably protect 10 square feet of area, the manufacturers of automatic sprinkler equipment very often plan and install sprinkler equipment so that one head is placed to considerably less than 10 square feet of area, which makes, under the rules of the National Board of Fire Underwriters, the larger size service connection necessary.

The use of water from the fire service for other purposes than extinguishing fire is a problem which confronts the waterworks executive, and is generally dealt with either by sealing and inspecting all drip valves on the system, or by placing some form of meter or detector in the service line. In my judgment, a clear distinction should be made between supplies to be used for extinguishing fires and those to be used for domestic purposes, and under no consideration should domestic service be taken from a fire supply line. The charge made for private fire service should include water consumed for periodical testing of the system, losses from evaporation and water used for extinguishing fires. This being the case, it is only necessary to introduce in the service connection a device which will indicate that water has been used. The question of how much is not important. This will effectually prevent continuous use of water for any purpose other than that for which the service is installed. If it is found, for instance, that the service is used more frequently than would be necessary for inspection or make-up water, inquiry can be promptly made and the proper remedy applied. It is, I think, important that the consumer to whom private fire service is supplied should be required to

give a bond of sufficient size to guarantee fulfilment of contract provisions. There is also the necessity for the adoption of uniform practice in this respect by all waterworks operated under the same general conditions.

The next problem which confronts the waterworks executive is that of meters, and there is little question but the selection of water meters is a problem to every waterworks executive. This problem is more complicated in a municipality where the charter and ordinance provisions are in force similar to those in St. Paul, where the central purchasing agent is required to award a contract for purchases exceeding in amount $500, upon formal bids, to the lowest responsible bidder. This makes it necessary for the executive to prepare specifications which will either represent the water meter his judgment considers the best, which would be considered discriminatory, or else prepare an open specification which shall permit the manufacturers of all water meters to bid and be satisfied to accept that meter which will be furnished for the lowest price. Two years ago, when this provision was first in effect in St. Paul, bids were received for water meters upon a general specification, and after tabulation, the contract committee asked the writer to make a recommendation. Knowing full well the provisions of the charter with respect to purchases of all supplies, the following recommendation was made:—

"It is my judgment that the city should buy that meter which, in addition to complying in all respects with the specifications, represents the lowest unit cost during its life, the determination of which involves an equation having only one known quantity (first cost) and several unknown quantities."

For both service connections and meters, history cards are started when the service connection is installed or the meter is purchased. Upon these cards are recorded all that happens to the service connection or the meter, including all elements of expense. These cards are found of great value because they represent the life history of either the service connection or the meter.

The problems involved in the material and supplies division are very interesting. Time will not permit their analysis in this paper.

The accounts division is of great importance, but is not always given the attention it should have.

The water revenue division, as you well know, represents the activities of the department of the waterworks which come in direct contact with the public. On this account many problems are involved, particularly in its organization and administration. You will note that the organization of the St. Paul waterworks is administered by a registrar who directs all of the subdivisions. These sub-divisions are made so that each man has a separate and distinct branch of business to transact, affording the person who has business with the department the facility of transacting it rapidly and avoiding what is so common, being referred from one division to another. Information and complaints are given very careful consideration in our organization, and the heads of these sub-divisions are trained and cautioned to always assume that every complaint is real to the complainant and not to take uncomplimentary remarks about the department as personal. It is here that calmness and courtesy count; our slogan is "Service."

In making up the organization chart to which reference has been made, it is intended to classify and group the different functions logically, making a single officer responsible to the general superintendent for the direction of each function. The functions of each sub-division have been clearly defined by bulletin and the duties and lines of authority of each position have been standardized and defined. While experience has shown that this organization has operated smoothly and accomplished very definite and satisfactory results, it is also shown that slight readjustment in some of the divisions will give better results and these changes will be made at an early date. An executive must train himself to be awake, to make changes in his organization when experience shows that the change is necessary and will effect an improvement in administration.

OTTAWA AND ST. LAWRENCE RIVER REGULATIONS.*

By C. R. Coutlee, M.Can.Soc.C.E.,
Engineer in Charge, Ottawa River Storage.

THE St. Lawrence valley extends as far into America as the Mediterranean extends into Europe—two thousand miles. The St. Lawrence River, of which the Ottawa is a tributary, has a basin of about half a million miles. Montreal is about half-way of the river's length, and also marks about half the basin area.

The basin produces trees, grain, grasses, iron, minerals and water power. It is probably the best home in the world for whites, but owing to the severe winter practically half the year is lost in the Canadian part of the basin.

Excepting the Ottawa, none of its tributaries are very large. The Great Lakes form natural storage, amounting to one hundred thousand square miles, but the connecting channels require to be dammed and throttled in order that the storage may be used to full advantage.

The river is an international stream, and consequently suffers from divided ownership. Again, it is bordered by provinces, states and powerful municipalities, so that harmonious work towards betterment is impracticable.

Besides its natural use for water supply and recreation it is artificially used for navigation and water power and is misused as a cesspool.

Power bids fair to become the most important use of the river, because the navigation from Niagara to Montreal is a comparatively small tonnage of one or two million tons against sixty million tons between Lake Superior and Lake Erie.

The river now produces about half a million horsepower, but at the end of this century it should produce six or seven million horse-power. This could be brought about by co-operation between the United States Federal Government and the Canadian Federal Government.

(1) By buying out all the powers along the main river at present situated at the Sault, Niagara Falls and Massena.

(2) By constructing regulating dams at each change of level from Lake Superior to the sea.

*From paper read before the Ottawa Branch Canadian Society of Civil Engineers, March 15, 1917.

(3) By establishing special damage courts to settle inundation claims.

(4) By constructing ideal developments at each concentration of fall, the energy to be transmitted and sold for specific purposes—transport, chemical reduction and manufacturing—possibly in the distant future for heat.

A proposed concentration is as follows:—

		Horse-power.
(1)	Soo, 18-ft. fall	80,000
(2)	Detroit regulation dam and lock	30,000
(3)	Niagara and other passes	2,000,000
(4)	Whirlpool	2,000,000
(5)	Iroquois	290,000
(6)	Morrisburg	190,000
(7)	Cornwall	700,000
(8)	Coteau Fort	255,000
(9)	Cedars	500,000
(10)	Cascades	190,000
(11)	Lachine	380,000
(12)	Montreal	315,000
		6,930,000

Turning now to the Ottawa valley, which is 55,000 square miles, about one-tenth of the whole St. Lawrence valley, the main stream could be concentrated as follows:—

	Horse-power.
Above Quinze only rough information	125,000
Quinze	200,000
Temiskaming to Mattawa	140,000
Dieux Rivieres	50,000
Rocher Capitain	100,000
Des Joachims	65,000
Paquette	35,000
Calumet and Rocher Fendu	100,000
Cheneaux	70,000
Chats	125,000
Chaudiere	165,000
Greece Pointe	80,000
Carillon	165,000
Back River	150,000
	1,570,000

Dealing with the St. Lawrence and Ottawa Rivers alone and west of Montreal only, there might be developed:—

On St. Lawrence, six millions horse power, half Canadian, half American.

On Ottawa, one and a half millions horse-power, all Canadian.

It would cost half a million dollars to concentrate the St. Lawrence and over a hundred million to concentrate the falls on the Ottawa.

Navigation is carried on for six months each year. Upon the St. Lawrence it approximates eighty million tons between Lakes Superior and Erie. Of this, 80 per cent. is American coal and iron between Pittsburg and Duluth, which will never go farther east. Between Niagara and Montreal the navigation dwindles down to only 3 per cent. of the upper lake traffic. From the port of Montreal about two million tons are carried out to sea each summer. The sudden drop in tonnage between Niagara and Montreal is due partly to the half-year of winter and partly to the small amount of rough freight from the west to Montreal. When the Hudson Bay route is in operation the tonnage to Montreal will be still less. Navigation is thus becoming of entirely secondary importance to power on the St. Lawrence above Montreal and no navigation of consequence has ever existed upon the Ottawa. Between Niagara and Montreal power must now replace navigation as an international concern. There is a clear three million horse-power for each nation on the St. Lawrence and an additional million and a half for Canada alone on the Ottawa. This paper is not concerned with powers on the tributaries of the Ottawa and St. Lawrence; they are left to the promoter and the financial juggler.

When Cartier came to Montreal Island in 1535 he had to row up from Quebec, because even his little schooners were, as the rivermen say, "too long in the legs." Champlain did likewise, and so did everyone else until 1840. Then John Kennedy got to work and now there is a submerged canal from Montreal down, giving 35 feet draught. Currents yet exist, however, and a ship is always in peril of running on to the edge of the dredged channel or colliding with other ships. The improved channel is also lowering the surface and reducing the depth. Here, then, is another chance for a dam, and a big one—a rock-fill of sixty-six million cubic yards, with regulation sluices capable of passing 750,000 cubic feet second. The experience on the Winnipeg River for the past twenty years and on the Ottawa for the past five years shows that the rock-fill type actually becomes a part of the geology of the country.

The dam proposed would preferably be at Tadousac, 100 miles below Quebec. There would be a twin lock of Panama Canal size lifting up to the slack water pond extending 270 miles to Montreal. The pond surface would be slightly above the high tide level and be controlled by regulation sluiceways of ample size to ensure discharge between tides without currents over three miles per hour.

The new surface curve from Tadousac to Montreal would, of course, flood property, and a special damage court, as mentioned previously, is required to settle claims.

The channel to Montreal will at once be made forty feet deep and over and the danger of currents overcome. In winter surface ice alone without frazil would be formed. This on a slack water reach could be broken in March, so that the port of Montreal would be opened a month earlier.

The slack water reaches above Montreal would prevent the formation of frazil to drift down to Lake St. Louis and the harbor. A ship arriving at Montreal would not have to contend with river currents while docking.

There might, when the business of the water powers demand it, be a ship route by Lake St. Louis, Lake of Two Mountains and the Ottawa River to Hawkesbury, thence across country by the valley of the South Nation to the foot of Lake Ontario, near Cardinal. This would be an interior route and allow of ocean boats reaching Ottawa city, and eventually power sites farther west on the Ottawa as well as those on the St. Lawrence.

The concentration of falls on the St. Lawrence, especially between Prescott and Lachine, would adversely affect the steamship tourist business. Steel chutes at each dam, however, are quite possible to build, and down these a steamer load of tourists will experience all the necessary thrills.

The Whirlpool dam below Niagara Falls, proposed by Dr. T. Kennard Thomson, of New York, will extend this tourist route up to the very foot of the falls themselves, while an additional two million horse-power will be available for the general public.

Niagara Falls have been the constant care of hysterically artistic amateurs of both sexes for many moons. At present my friend, Mr. Isham Randolph, of Chicago, sleeps uneasily and dreams that in a few centuries the magnificent curtain will have become a decrepit rapid, trickling through crevices or gurgling down gopher holes —"unwept, uncoffined and unsung."

Now, why not divert all the water into power that tends to ruin the venerable escarpment, replacing it by a cupid breathing spray from perforated pipes led around the crest? Even the outline of the Indian maid with her white canoe could be produced, and in wintry nights it could be electrically heated or shut off altogether.

Anyway, the possibilities of joint ownership and development by two nations of the greatest power centre in the world have been outlined. It may be assailed as a flight of imagination—well, so was the electric light, the telephone, a few decades gone by. Two generations will accomplish this ideal for the world's greatest valley.

ROAD CONSTRUCTION.*

By M. A. Lyons,
Chief Engineer, Good Roads Board, Manitoba.

IN presenting the subject of road construction for your consideration it is not my intention to go into details, but rather to ascertain what basic principles the ratepayers and councillors must follow in order to obtain the best results from money expended.

While it is essential to give careful consideration to the economic and financial questions of road building, those are only subsidiary to the actual construction. It is possible to have good roads without good financing, but it is not possible to have good roads without proper methods of building them. The construction of the road is then the object of the other considerations, and it is in construction that money is spent. It is, therefore, necessary to investigate the fundamental principles governing this subject.

There are three elementary principles underlying economical and efficient construction. The first is the proper planning of the work so that necessary provision is made for drainage, the best alignment is selected, the economical grades established, and the proper shape of the road decided on. These matters come under the principle of good engineering. The second is the selection of the men, teams and machinery to do the work, and, most important of all is this division, the selection of an experienced and competent foreman. These matters are embodied in the principle of organization. The third principle is the planning of how the work is to be carried out, at which point the work will be started, in which sequence it will be followed up, and whether or not the work will be continuous. These matters are included in the principle of system. The three principles, good engineering, good organization, and the systematic carrying out of the work are the vital elements in road construction.

First, the engineering side of construction. What bearing has engineering on proper road construction? Three essential requisites for construction of a good road are drainage, grade and alignment. Drainage, drainage, and more drainage, is the slogan of all road builders.

*Abstract of paper read before the Manitoba Good Roads Association.

In rolling country or open soil the drainage may not be a difficult question, but in a level country with heavy soil it often becomes a most difficult problem. Here skilful engineering is required to obtain proper grades for the drainage ditches and to locate offtakes which will carry the water away from the road ditches to natural watercourses so that the road may dry quickly after rains or in the spring. The question of grade is also one requiring careful consideration. Not only grade reduction on steep hills, but also the grade through rolling and through level country. In level country the road will be constructed of material from the ditch. Very rarely is a country so level that the quantity of earth taken out of a ditch is the same at every point in the ditch. Some places there will be more earth than is required for the building of the road at that point and at other places not sufficient. Careful thought must be given to the disposal of this earth, whether it should be hauled from places of heavy cut to places of light cut or whether some of it should be wasted and earth borrowed at the light cuts. In rolling country, where little ditching is necessary, the grade must be so planned that the cut from the hills must just balance the fills up to an economical length of haul, which length of haul must be determined. In grade reduction on hills the problem is to establish the most economical grade. This grade will vary with the relation of the cost of the grade reduction to the amount and nature of the traffic. It will be dependent on the direction of heavy traffic, the type of road, or perhaps be governed by a ruling grade on some other portion of the road.

A proper alignment of the road is necessary, both for appearance and economy. In level country a well-aligned road grade and ditch has an appearance in keeping with a neat farmyard and farm buildings. On side hill work a change in alignment may make a considerable change in the grade of the road or in the cost of construction. In rolling country it is often found more economical to build a road around a hill than to build over the hill and thus reduce a heavy grade to a level or nearly level grade.

The shape of the road is also an important question to be decided. It must be wide enough to conveniently accommodate the traffic which will make use of it, but no wider than is necessary or the expense of maintenance will be too high. The width of the road will vary according to the class and amount of traffic. In general, an eighteen-foot road is the minimum width on which two lines of traffic can comfortably pass, especially if some of this traffic is fast moving. On reads where the traffic is light and slow moving a sixteen-foot road may suffice.

The location and size of ditches must also be given consideration. The ditches must be so planned and constructed that the road will be safe for traffic. The location, size and shape of the ditch will vary with the class of road, with the nature of the soil and with the topography of the country. The crown of the road must be such that any water falling on it can quickly find its way to the ditch. But the crown must be no more than is necessary to serve this purpose. The amount of crown will vary with the type of road, with the grade of the road and with the character of the soil.

From these considerations it is apparent that engineering plays a very important and essential part in road construction.

The part which the organization has in road-making is also very important. It is useless to plan proper drains, grades, road sections and alignment unless the construc-

tion of these is properly carried out. It is also necessary to carry this work out in the most economical way, as it is here that a lot of money spent in building roads is utterly wasted. A good organization requires the use of tools and machinery suitable for the type and amount of road which is being built. A slip scraper where necessary and a wheel scraper where it is necessary, a push grader in its proper place and an elevator grader in its place; team hauling of material where that is economical and hauling by tractors where these prove economical. Each of these have their place, and a proper organization will use each in its right place. The number of teams and men must suit the requirements of the road under construction. Too many men and teams, and they will be in each other's way. Too few, and the work will not be carried out economically. Most important of all is a good foreman, who knows what is required and how to get the desired results. Under a good foreman every team and every man is in the right place.

Under proper organization the men soon discover how each portion of the work can be most easily carried out and just what work should be done. No time is wasted getting started and no unnecessary labor performed when they are at work. A man on work with which he is familiar will certainly show better results than one unaccustomed to that work. The effect of this knowledge will be shown in a lowered cost and a better job of construction. Good organization, therefore, not only insures that the road will be properly constructed, but that it will be economically constructed.

The third principle of proper road construction is the systematic carrying out of the work. For the best results the whole road scheme should be planned in advance and every piece of work done towards the completion of that scheme. It is not meant by this that every piece of road on which work is done should be at once constructed as a finished road, as financial conditions will not always allow this, but whatever work is done should be a step towards the completion of the finished road. This systematic construction is very important where drainage is necessary. The only proper place to start a road drain is at its outlet and the work carried towards its upper end. The mile of road which is most used is the one next to the market. It is, therefore, reasonable that the roads nearest the market should be built up first and the system added to each year as far as possible. It is only by this systematic carrying out of road construction that a satisfactory scheme of roads will ever be provided.

These three principles, then, engineering, organization and a systematic scheme of road-building are the three essential elements for road construction. If these are attended to good roads will result.

An exemplification of the results of adopting correct principles for road construction is seen in England. This country, after struggling in mud for fourteen hundred years, applied these principles which we have just considered under the supervision of John MacAdam. From that time onward England's roads rapidly developed. Shortly after this, England also began to develop industrially. With the experience of our Mother Country before us as well as the experience of other countries, we must be classed as dull children in this respect if we do not adopt these fundamental principles in our road construction. All ratepayers will not be building roads, but all can use their influence to have road construction in their municipality carried out under proper engineering, good organization and in a systematic manner.

PLANNING THE DISTRIBUTION OF THE WATER SUPPLY OF A SMALL TOWN.*

By M'Kean Mallitt,
Superintendent Water and Sewers, Florence, S.C.

HAVING determined the necessary supply, storage and filtration of the new water system, it becomes necessary to take up the distribution of the supply. The term "distribution" covers all the operations of the plant from the filtered or clear water reservoir up to the point where the water is delivered to the consumer.

The Method of Distribution.—Distribution of supply is one of two main kinds, gravity or pumping; in rare cases both gravity and pumping are resorted to. Where the topography is suitable a purely gravity supply can often be developed that will need neither purification nor pumping. In cases of this kind, there are but few points as to capacity of supply and distribution to be considered. However, in most cases it is necessary either to purify or to pump the water, or both. In some cases there is a combination of direct pumping to reservoir and gravity distribution from the reservoir to the consumer. These conditions favor the most economical rate of pumping, provided the reservoir can be made of sufficient size to accommodate all variations in demand, and is high enough to give sufficient pressure for all fire and domestic purposes.

Where the reservoir site is of the above nature, the pumps can be designed for a nearly constant speed and for a constant head, and neither will materially change except as there are changes in the water level in the reservoir, and these changes will be seasonal rather than daily or weekly. Pumps designed for such conditions can be operated at a much more economical load than can pumps that are designed to operate part of the time at one speed and head and part of the time at another speed and head. Such conditions will be ideal from an operating point of view, and the only objection to them is that there may be a rather high capital charge for the installation. This should be carefully watched to be sure that what is saved at one place is not lost at another. Locations such as this should be most carefully planned so that there will be sufficient capacity in the mains to and from the reservoir, especially from the reservoir. Particular attention should be paid to the size of the outlet, lest it be too small for the supply, as it will have to work under a very little head of water and its capacity will be governed thereby. Then there should be a duplicate main in the principal distribution system to prevent a water famine in case there is a failure in one main. The capital charges on this duplicate main may be very large, as the site of the reservoir may be at some distance from the city.

In case the reservoir site is upon the top or the side of a hill sufficient diamond drill borings should be made to determine the condition of the underlying strata. Do not think that because it is a hill it is as strong as the hills. There may be an underlying stratum that will be of insufficient strength to carry the additional load imposed upon it by the erection of a reservoir on its top. Or leaks may develop in the reservoir that will so saturate the underlying strata that they will become too unstable to carry the load. These points may seem far-fetched or unreasonable, yet they are possibilities and grave ones, and must be investigated. In any case, the design of a gravity system should be such that it will be as easily controlled as a pumping system.

*From "The American City."

If the topography is not suitable for a gravity system, there remains only the pumping system. Knowing the greatest quantity of water necessary for all purposes, design the pumping equipment with two or more units for the care of the maximum demand at normal speed and rated load. Then one unit can care for all domestic consumption and most of the smaller fires, and the other unit can be held in reserve for large fires and as a relief unit. In case of extra heavy loads for short periods, both units can be operated at a considerable overload for such emergencies. Under no conditions depend on single units in any part of the system where it is possible to install duplicates or more.

Selecting the Pumps.—The selection of type or design of pumps is so dependent upon operation conditions and power supply that it is possible only to mention here the different types, such as: direct-acting plunger pumps, steam, electrical or belt-driven; centrifugal pumps, steam, electrical or belt-driven. Each type has its advantages and its disadvantages, and local conditions of supply and demand and power supply will govern selection of type. In general, it may be said that in any type of piston pump, slow speed and long stroke should be the objects sought, as they are the more satisfactory from an operating point of view. In centrifugal pumps, not too high speed and as near as possible a constant head discharge are the desirable conditions. Too great speed causes too great friction in the pump and accentuates erosion in case there happens to be the least sediment in the water. Too irregular head lowers the efficiency curve of the pump, thereby losing overall efficiency in the plant. This, however, may be offset by the other advantages of the centrifugal pump.

The three main sources of power are steam, central station current and internal combustion engines. Here again local conditions will govern the selection of the type of power plant. Where coal is high and hard to get, with a reasonable oil rate, there may be great advantage in adopting an oil engine main drive and electric sub-drives throughout the plant. Where there are large, well-regulated central stations giving first-class service at reasonable rates, there may be advantage in central station current. Where coal is cheap and deliveries are good, then steam may be the cheapest and the best power to be had.

In any case there must be break-down or reserve service. Central station current will require steam or oil engine reserve. Oil engines will have to be in duplicate and steam will have to have duplicate equipment. With regular central station service there is the great danger of allowing the reserve plant to get in bad shape, especially in the smaller cities. This should never be countenanced, and to be sure that there is a reserve plant ready at all times the steam plant should be run at least one week in every month. No operating engineer can lay by a steam or oil engine plant for thirty, sixty or ninety days and be sure that it will operate successfully at a moment's notice, and that is all the notice that one gets from central station service, even if that much. The writer is of the opinion that with properly designed boiler settings, engines and auxiliaries and with coal at not over $4 per ton, there is small chance for the central station to carry the load at its commercial rates. If current costs less than one cent per k.w.h., there may be reason for trying the central station current.

There are the usual charges against whatever power adopted, such as interest, depreciation, operating repairs, replacement costs and general operation expense. In steam-driven pumps there are the items of valves, packings, lubricating oils, slippage, water hammer, attention, etc., that must not be overlooked. In centrifugal pumps, the items of valves, packings and lubricating oils can generally be ignored, as they are very small. Slippage also is a negligible quantity unless the water is gritty or acid or the excessive speed causes severe erosion of working parts. Each class of pump must bear its own load, and where there are necessary auxiliaries for any of the main units the operation and upkeep of these must be charged to the main unit in figuring the cost per 1,000 gallons pumped.

The Layout of the Mains.—The layout of the mains for the distribution of the water is governed mostly by the congestion of the buildings and the general direction of expansion, though the distances through which the mains have to be laid is an important factor. There have been so many cases where water plants have had to replace all small mains at great cost before the material in the lines had begun to deteriorate to any extent that it seems hardly necessary to call attention to this point, though the failure to provide against it in many cases may be caused by not giving it sufficient thought in the beginning. From the operator's point of view, mains can hardly be too large, whereas in general practice they are very seldom large enough for ordinary purposes. The difference in first cost is so little that there is no reason why they should be restricted in size. The following table, arranged by the writer for comparison purposes, when pipe and other supplies were normal, may throw a little light on the subject:—

Size main inches.	Cost foot.	Unit capacity.	Cost unit capacity.
4	$0.40	1	$0.40
6	0.60	2	0.30
8	0.80	4	0.20
10	1.00	6	0.16
12	1.50	9	0.16

The table shows that where a 4-inch main is run at a cost of 40 cents a foot the unit capacity is only one, whereas by doubling the cost per foot the unit capacity is quadrupled and the cost per unit of capacity is cut in half.

As far as the writer knows, there is no method or formula by which the proper size of main can be figured, and it is general practice to use the best judgment of the engineer or the superintendent to suggest proper sizes. This is entirely wrong; the sizes should be governed by the uses to which they are to be put. Cut the city into districts, segregate each district, calculate the maximum capacity demanded for each, and lay the mains of sufficient size to care for that demand. See that each district has feeders large enough to supply the demand, then tie all the districts together in gridiron fashion, and there will be small chance of the mains being too small. No matter if the investment is a little large at first, it will pay in the end to have mains that are large enough to stand the service and will not have to be torn out in a few years.

In the average residence section where the buildings are not congested to too great an extent and where there is a good gridiron lay-out of mains, the minimum size should be 8 inches and there should be much larger feeders, or belt lines that act as feeders. If the pressure happens to be very low and thereby calls for pumping units in the fire department, the minimum size should be 10 inches. A main of this size can generally be depended upon to furnish sufficient water in residence sections to

meet all demands and not to limit the use of the water by the fire department to one or two hydrants when five or six are needed.

The Fire Hydrants.—The location of fire hydrants is a mooted question and should receive careful consideration. The general haphazard manner of locating a hydrant on each corner is like all the other hit-and-miss plans used. The best practice is to so lay out the hydrants that there will be one hydrant within a predetermined distance of any building that is to be protected. The writer believes in locating hydrants at least every 300 feet on all streets, and closer in the congested districts. In congested districts where there are great fire risks, hydrants should be not over 100 feet apart and located on alternate sides of the street. This will allow for one entire sidewalk to be blocked by falling buildings, and still have a hydrant every 200 feet on the other side of the street.

In normal times the cost of a good hydrant and branch line valve set up is not over $50 and the hydrant is good for at least twenty years, but with proper attention it will last as long as the mains last. Fire hose costs from 80 cents to $1.10 per foot and lasts about five years where not very much use is made of it, and proportionately less where it is used regularly. So the location of hydrants at closely spaced intervals will eliminate almost all long lines of fire hose and will materially reduce the fire department's expense for fire hose, to say nothing of being able to get the full benefit of the hydrant pressure on the hose.

In case the mains carry sufficient pressure for fire-fighting, the hydrants should have 6-inch or 8-inch connection to the mains and three or four regular 2½-inch openings or nozzles. Where the pressure is so low that the fire department has to repump the water, the hydrant should have not less than an 8-inch connection to the main and two or three 4-inch openings or nozzles. These conditions will allow the fire department to concentrate several streams on one fire and have no very long lines of hose on any of them.

The Eureka Fire Hose Company has published a chart showing that for 250 gallons of water per minute from one 1⅛-inch nozzle with 200 feet of hose it requires only 55 pounds hydrant pressure, whereas with 600 feet of hose it requires 95 pounds hydrant pressure, and with 1,500 feet of hose it requires 195 pounds hydrant pressure for the same amount of water. This shows that the closer spaced hydrants are the most advantageous as well as the most economical.

In selecting the type of fire hydrant, first cost should be the last consideration. Ease of operation, delivery capacity, accessibility of parts for repairs, low liability of breakage, and rugged construction should be the main features in any type. All types, however, should open against the pressure where it is possible. In case there is liability of heavy increase of pressure, this is an important factor in the hydrant, as small leaks under normal pressure become dangerous leaks under increased pressure when the hydrant valve opens with the flow of water. In any case, a gate valve should be placed on the branch line to the hydrant so that there may be no need of cutting out a whole block or section to make repairs to one hydrant.

Laying the Service Lines.—In the service layout of the plant great care should be taken to see that the pipe lines are properly laid and that there are no chances for them to be broken off at the main by the settlement of either the main or the branch line. Also, a good and strong curb cock or cut-off should be placed at the curb line, so that there will be a place at which the service can be controlled. In selecting the material for the service lines, it must be borne in mind that the line is put there for a permanent improvement and not as a temporary fixture. Too many engineers and superintendents reason that there is small chance for the use of the curb cut-off and that therefore it may be of a cheap design. This is wrong, especially in view of the very fact that it may lie idle for such a long time. After a long time out of use, unless it be of the very best, it will invariably give trouble when put in use again.

No service on any water plant should be without the proper measuring device where it enters the property, no matter if the supply of water be unlimited and there be no apparent chance of ever using all of it. Water should be sold for use and not for waste, and the only way to sell it for use is to make those that get it pay for it. Then if they want to waste it they can waste it, but they will pay for it just the same. With no meters and with flat rates for consumers, there is great danger that the service fixtures may leak badly and put such a drain on the mains that there will be small capacity for the fighting of fires. Ellis says that a circular orifice one-sixteenth of an inch in diameter working under 50 pounds pressure per square inch will deliver 1,180 gallons of water per day. So in case there be 1,000 consumers who have no meters and only one one-sixteenth-inch leak each, it will require 1,180,000 gallons of water per day for that waste.

SUGGESTED NEW DOCK SITE FOR ST. JOHN, NEW BRUNSWICK.

Mr. William Murdock, city engineer of St. John, N.B., in his annual report just issued, makes some very important suggestions in connection with improvements to the docking facilities of the harbor there. He suggests that a new dock site be built at Rodney Slip and extend 2,000 feet, reaching the upper end of Navy Island.

He refers to it as "a dock site which commends itself highly among the possibilities of St. John harbor, as being well in from storms, entirely free from ice and strong currents, would give 3,800 lineal feet of wharf front, and be centrally situated on the line of the proposed harbor bridge. Borings have shown that such a wharf could have thirty-five feet in depth of water, along the entire front named, without excavating rock. The greater part or all of the material removed could be deposited by suction dredges on the land between Navy Island and the northern end of the wharf. Two thousand feet of continuous frontage would be available on the eastern side, 1,500 feet on the western side, and 300 feet across the southern end. The northern end would be exposed to the strong river currents and, perhaps, not be desirable. The railway track on Union Street West, could be extended northward, eastward and southward via Middle and Nelson Streets and the ledge which connects the island with Carleton at low water. Here a trestle would be advisable that the tide could flow west of Navy Island as it does at present.

"Such a wharf would require removal of the ferry dock, which could be changed at a minimum expense to the head of Rodney Slip, as shown on the plan. The tramway down South Rodney Wharf would be discontinued and the wharf restored for shipping as of yore, thus liberating to the small craft a frontage of about 1,000 feet, whilst Nelson, Wellington and King Street slips would be available as now."

HIGHWAY TRAFFIC ANALYSIS AND TRAFFIC CENSUS PROCEDURE.*

By William H. Connell,
Chief, Bureau of Highways and Street Cleaning,
Philadelphia, Pa.

WITH traffic increasing at such an alarming rate, the street traffic problem, both with reference to the varying widths of streets and the wear and tear on the pavements, is one of the most serious ones the engineer has to contend with to-day.

With the present rate of increase, before very long it will be necessary to designate certain north and south and east and west streets for passenger traffic, and other ones for the business traffic, consisting of delivery wagons and trucks, both automobile and horse-drawn.

The number of automobiles in the city of Philadelphia in 1912 was less than 9,000; in 1914 nearly 17,000, while to-day there are over 35,000, or about four times the number there were in 1912, and twice as many as in 1914, and the traffic is from three to five times as heavy on a number of our main automobile thoroughfares as it was in 1914, and there is no reason why we should not expect traffic to practically double in the next two years, as the maximum will not be reached for some years. The cost of automobiles will gradually decrease, and in like proportion the number will increase. They are no longer a luxury, but more or less of a necessity. All the people are waiting for is a lower first cost, and a cheaper fuel, both of which are in store for the future.

Though the fundamental purpose of a highway is to carry surface traffic, the lack of foresight, due largely to the absence of studies relative to future traffic considerations, has resulted to a considerable extent in the conditions existing in most municipalities to-day where both the general plans and widths of many highways and the characters of their pavements are largely or entirely inconsistent with the traffic requirements to which the highway is subjected. Traffic planning is a problem in itself. Its purposes should be to develop closer and more consistent relations between probable traffic requirements and existing and proposed traffic provisions.

The operations constituting the general function of traffic study may be properly sub-divided into two general classifications as governed by the purposes and nature of the data to be obtained and of the methods of investigation involved.

Traffic Survey, which has to do with the investigation of the physical and other conditions influencing or relating to the carrying of proposed or existing highway traffic.

Traffic Census, which has to do with investigation of the quantity, character, weights and other conditions of traffic.

A system of traffic study, to be complete and comprehensive, should provide ample data for a full consideration of the following features:—

The Plan of the Highway: Including the consideration of the use of curved, rectangular or diagonal lines, and of the necessity and location of traffic circuit highways; the determination of the grade; the number and desirable width of the roadways and footways to accommodate present and probable future traffic requirements; and the possibility of devoting certain spaces to the purposes of temporary or permanent lawn or planting areas.

The Design of the Pavement: Including the advisability of improving the full legal width of the roadway and footways, and the selection of the types of pavement surfaces and base course construction best suited to the requirements of the prevailing traffic.

The Maintenance of the Pavements: Including the study of the depreciation and maintenance costs per unit of traffic and of the physical effects of traffic upon the pavement surfaces with respect to total and unit vehicle loads, width and character of tires, speed, and non-skidding and braking devices.

The Cleaning of Highways: Including the determination of the kind of cleaning best suited to the existing type of pavement and the prevailing character of traffic and of the hours during which the cleaning may be performed with the least interference or inconvenience to traffic.

Traffic Regulations: Including the assignment of definite highways for specific classes and directions of traffic; the designation of parking areas for automobiles and other vehicles; the establishment of pedestrian crossings and safety islands and zones; the determination of the most suitable location for proposed street railway tracks and the consideration of the advisability of relocating existing tracks; and the establishment of a general system of control by signal devices or otherwise to insure safety and to eliminate entirely or reduce to a minimum the congestion of both vehicular and pedestrian traffic.

Traffic Units.—Like many other engineering determinations, no standard methods have been universally adopted for the classification of traffic; for the taking of traffic census data; or for the reduction of the census data to definite units. While most traffic censuses are conducted along the same general principles, yet the absence of a uniformity of details and especially of a generally recognized standard traffic unit has confined the value of most traffic census data largely to the purposes of local comparison. The character of the data should, nevertheless, be such as to permit it, in addition to being used for local comparative purposes, being also studied in connection with data taken in similar situations in other localities.

In most traffic censuses conducted thus far, it has been the general practice to consider as a proper traffic unit the value expressed by the term "ton of traffic per foot width of pavement," which is based upon the total load passing over the entire width of the pavement in a measured period of time. This is misleading, and practically worthless, as a factor to be used in connection with the designing of a suitable type of pavement, due to the fact that in most cases only a relatively small portion of the width of a roadway carries the maximum traffic load, while the remainder carries comparatively little traffic.

A pavement to be used in any specific situation must, of course, be practically of a uniform character of material and this makes it all the more necessary that the selected type of pavement be capable of performing satisfactory service at the point of maximum wear which necessarily lies within the maximum travelled width of the pavement and especially in the tire paths.

The segregation of moving traffic is due to several causes, principal among which may be included the parking of vehicles along the curbs or in the centre of highways, and the presence or absence of railway tracks.

It is obvious, therefore, that the maximum travelled width or that width of the roadway subjected to moving traffic rarely equals the total width of the roadway. In each case, however, the approximate travelled width

*Abstract of paper read before the American Association for the Advancement of Science.

should be carefully investigated. In most cases it will be found to vary only between one and two times the average width of the prevailing type of vehicle, and in many other cases between one and several times the average width of each of the tire paths. The logical necessity for the consideration of the "maximum travelled width" in preference to the "entire width" of a roadway will be fully justified when it is considered that the unit "average tonnage per foot width of roadway" will give values far less than those given by the unit "average tonnage per foot of maximum travelled width of roadway."

For the purpose of the selection of a satisfactory type of roadway pavement for any given situation, it is also very necessary that the annual maintenance and the life cost (depreciation and interest on first cost) of the type of pavement under consideration per unit of traffic be known with some degree of certainty.

The most logical and satisfactory unit of traffic measurement yet proposed would seem to be the "ton-mile" or its multiples, such as "hundred-ton-mile," or "thousand-ton-mile." To obtain the actual ton-mile of traffic, the census figures that represent the maximum load should be reduced proportionately to give the average load.

The use of the "ton-mile" unit will not alter or render more difficult the general methods employed in the taking of traffic census data. It is only necessary that the observer be stationed in a block or stretch of highway of known length where every vehicle in passing the observation point must actually traverse a definite fractional part of a mile length of highway.

For the purpose of local comparison, it is seldom necessary to use more than one kind of traffic unit, but when it is desirable to provide data that may be compared with studies made in similar situations in other communities, any additional kinds of units that may be necessary should be used in order that the data may be reduced to comparable form.

Classification of Traffic.—As governed by the weights of vehicles and the characters of their tires, vehicular traffic should be divided into as many classifications as may be necessary to give fairly accurate results. In general, however, fourteen somewhat standard classifications have been proposed, which, while more or less arbitrary in determination, are nevertheless considered to be fairly representative of average traffic values. These several classifications are as follows:

Classification.	Character of traffic.	Average weight in short tons.
Horse-drawn—		
(1)	Horse without vehicle	.65
(2)	Light one-horse-drawn vehicle	1.20
(3)	Heavy one-horse-drawn vehicle	2.00
(4)	Light two-horse-drawn vehicle	2.00
(5)	Heavy two-horse-drawn vehicle	4.00
(6)	Three-horse-drawn vehicle	5.00
(7)	Four-horse-drawn vehicle	6.00
Motor-driven—		
(8)	Motorcycle or bicycle	.15
(9)	Two-passenger motor vehicle	1.30
(10)	Over two-passenger motor vehicle	2.30
(11)	Light freight motor truck	3.30
(12)	Medium freight motor truck	6.00
(13)	Heavy freight motor truck	8.50
Miscellaneous—		
(14)	Miscellaneous extra heavy traffic	As individually estimated

The terms "light," "medium" and "heavy," as used in these traffic classifications, are intended to indicate the maximum possible capacity of the vehicle and not the relative weight value of the load carried at the time of its observation. These classifications of traffic are only intended to serve for general purposes.

In determining the probable compressive, shearing and impact stresses produced in the pavement it will be necessary also to determine the maximum unit weights carried per inch effective width of tire. In this connection it should be noted that the several characters of tires in general use include both metal and smooth surfaced and non-skidding rubber tires of both the solid type and of the inflated type, and also caterpillar solid rubber tires and tires equipped with non-skidding devices.

Analysis of Traffic Census Data.—The data compiled from a systematic census count taken each year as being representative of the average traffic conditions prevailing throughout the year makes it possible to estimate very closely the total probable tonnage carried during the entire year. This data, when considered in conjunction with the records of the total annual charges for depreciation and interest on first cost and maintenance costs and the average travelled widths of the pavements, will give the following analysis:

Traffic tonnage—

(*a*) Total tons of traffic per year carried by the highway.

(*b*) Average tons of traffic per year per foot width of roadway pavement.

(*c*) Average tons of traffic per year per foot of maximum travelled width of roadway pavement.

(*d*) Total tonnage for life of pavement per foot width of roadway.

(*e*) Total tonnage for life of pavement per foot of maximum travelled width.

Ton-mile maintenance costs—

(*f*) Annual charges for depreciation and maintenance cost per ton-mile of traffic.

(*g*) Total charges for depreciation and maintenance cost per ton-mile for life of pavement.

(*h*) Average ton-mile of traffic per 1 cent of charges for average annual cost of pavement.

This data will show definitely the relations that actually exist between the traffic service and the depreciation and the maintenance costs of the pavement, which constitutes a most important factor to be considered in the selection of a type of pavement.

In 1913 seventeen of the largest water consumers of Johnstown, N.Y., who were in the business of leather dressing, used a total of 49,846,215 gal. of water for that year, compared with its use during the year 1916 of 260,468,087 gal., or an increase of 366 per cent. These seventeen services use one-third of the total water from the city's three sources of continuous supply.

Steel bars, plates and shapes have never sold higher in the history of the trade than the prices reported from Pittsburg as put into effect recently by the Carnegie Steel Co. Plates were advanced $15 a ton. Bars and shapes were put up $7 a ton, making the quotations 3.35 cents a pound for bars and 3.75 cents for shapes. On March 12th wire products were lifted $4 a ton, the entire development supplying the most spectacular week, so far as prices are concerned, since the current boom got under way. The enormous demand for ship plates from the yards at home and abroad has been the dominant factor in the plate price increase, and structural shapes have also been affected by the expanding shipbuilding industry.

THE LAYING OUT OF STREETS AND BOULEVARDS IN RELATION TO MODERN TOWN PLANNING.

By L. McLaren Hunter, C.E.,
City Engineer's Office, Ottawa.

AFTER the present war has finished vast sums of money will likely be expended on town and city planning in Canada. New towns will probably spring into existence, and in most cases the widening and the laying out of new streets and boulevards will be of the first importance. Mistakes which have been made in the past, especially in Eastern Canada, of laying out long and narrow streets, will not, probably, be made in the future.

Before dealing expressly with street design, it might be permissible to mention a few details which must not be overlooked in the planning of a modern city.

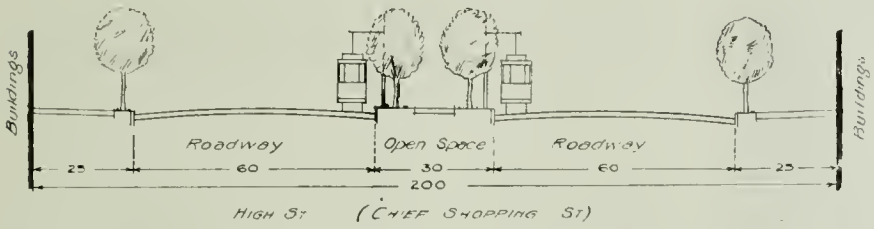


Fig. 1.

Every town or city will have its distinctive feature which will predominate the whole design. In a Capitol, the houses of parliament, and in most other cities the city hall will predominate. The social, civic and industrial

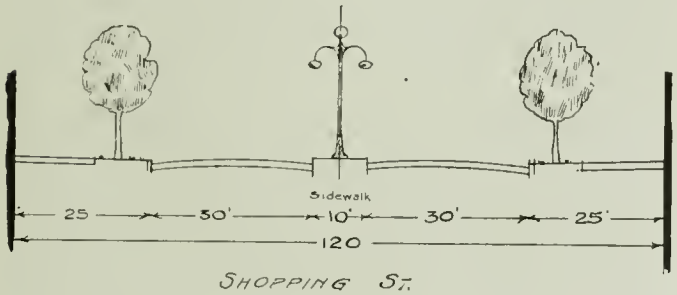


Fig. 2.

characteristics, along with the topographical character, have to be given their proper place in the design.

The first consideration is the health of the citizens; therefore in planning, proper provision must be made for an adequate water supply; secondly, a good sewerage and drainage system is necessary. The other essentials required are, proper scavenging and removal and disposal of house refuse. The construction of business and residential thoroughfares, boulevards and bridges, street railway system, gas and electricity for lighting and power; parks; recreation grounds and open spaces; architectural treatment of all public, industrial and residential buildings.

The first plan to be prepared should show all the natural features, such as woods, trees, rivers and hills; this plan should also have the contour lines marked upon it. Then we proceed to locate the different areas—government, civic commercial, industrial and residential.

The commercial area is usually placed between the civic and residential areas; the residential area, of course, occupying the outskirts of the city.

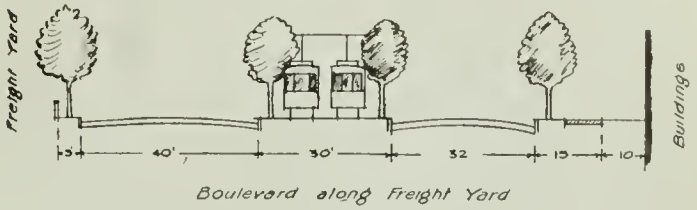


Fig. 3.

The location of industrial areas requires considerable study. The proximity to railways or canals has to be taken into consideration. This area must be located so that the prevailing winds will carry the smoke away from the shopping, civic and government centres.

The designing and laying out of the main thoroughfares and boulevards is a most important part of the modern city, for the beauty of a city entirely depends upon the laying out of its streets, boulevards, bridges and parks. The direction of the streets has to be studied, so that a view of the principal buildings may be obtained. Careful consideration has also to be given to the widths and grades, and in the plan, squares and crescents have to receive treatment.

In the business sections of a city the streets should be wide and direct, and it is essential that an easy grade is obtained. Fig. 1 shows the layout of the High Street (a chief shopping street) of the new federal capitol of Australia. This street is 200 feet wide, having 25-foot sidewalks on each side and two 50-foot roadways (on which the car tracks are placed). In the centre is a 30-foot plot of ground where two lines of shade trees are placed. This plot serves the double purpose of allowing passengers from the street cars to alight in safety, and also provides a cool resting place for tired shoppers.

This thoroughfare is almost ideal in layout but, unfortunately, few cities in Canada have the same opportunity as the capitol of Australia, where the land all belongs to the government, and where the sale of lots for building purposes will amply repay the government for the construction of wide streets and boulevards.

In Fig. 2 is shown a secondary shopping street of

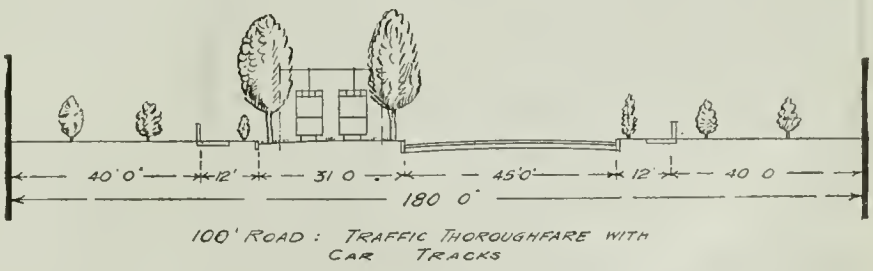


Fig. 4.

the Australian capitol. It is laid out on the same principle as the High Street, but is only 120 feet wide and has no car tracks. There are two roadways 30 feet wide with a 10-foot central sidewalk. On this sidewalk ornamental

posts are placed for street lights. There is a space of 25 feet allowed between the roads and the buildings, which is used for sidewalks and shade trees.

Industrial streets, or streets where heavy freight has to be handled, have to be treated in a different manner. The grades must be easy and allowance made for slow

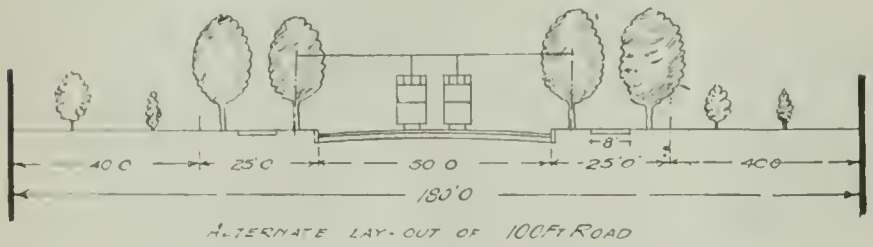


Fig. 5.

and rapid transit. In Folwell's "Municipal Engineering Practice" a good street layout is given where the freight yard is on one side and buildings on the other (Fig. 3). The side next the freight yard is taken up by a 5-foot strip with trees (to close the unsightly view of the yard) and a 40-foot allowance for heavy, slow-moving traffic. On the other side there is a 32-foot allowance for rapid transit and 25 feet between that and the buildings made

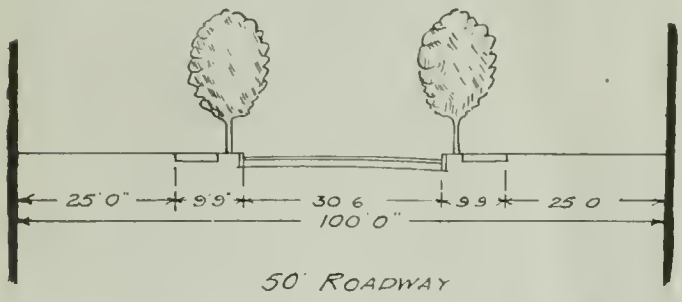


Fig. 6.

up of a 5-foot space for shade trees; 10 feet of sidewalk, and a 10-foot allowance for street cars with shade trees. Altogether giving a very pleasing appearance.

In dealing with residential areas, the methods used in planning should be entirely different from the business districts where rectangular and radiating systems are most suitable. Beauty in layout and economy in construction of residential streets should always be the rule.

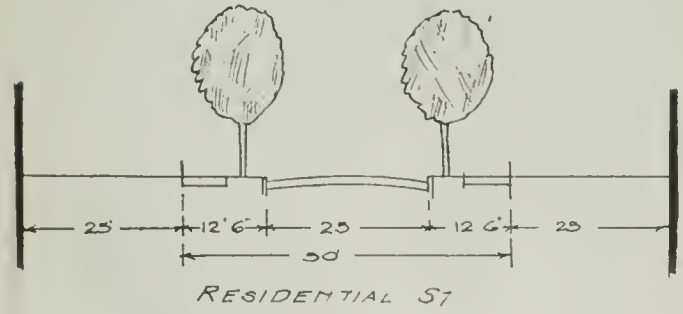


Fig. 7.

Circular, irregular and undulating boulevards give the most pleasing results.

In Figs. 4 and 5 alternate designs are shown for the layout of residential traffic thoroughfares with car tracks. These are the types permitted under the town-planning scheme of Great Yarmouth, England. The street is 100 feet wide, with 40-foot set-backs (or parterres) to the buildings. In Fig. 4 the track allowance of 31 feet is separated from the roadway by trees.

Fig. 6 shows an ordinary residential street (Great Yarmouth, England) 50 feet wide, made up of 30-foot 6-inch roadway, 9-foot 9-inch allowance for sidewalk and boulevard, with 25-foot set-back.

The Australian capitol has practically adopted the English layout for residential streets. Fig. 7 shows a section of a 50-foot road as planned for Australia. The roadway is made 25 feet wide.

Fig. 8 shows the American method of dealing with a residential street with car tracks, in the centre, 17-foot roads are shown on each side of the tracks for vehicular traffic.

In Folwell's "Municipal Engineering" the following widths are given as the standard for streets and boulevards:—

(1) Boulevards, thoroughfares with parkways, 150 to 300 feet wide; (2) waterfront streets and localities where freight is handled, 100 to 250 feet; (3) diagonal thoroughfares, 100 to 150 feet; (4) business thoroughfares, 100 to

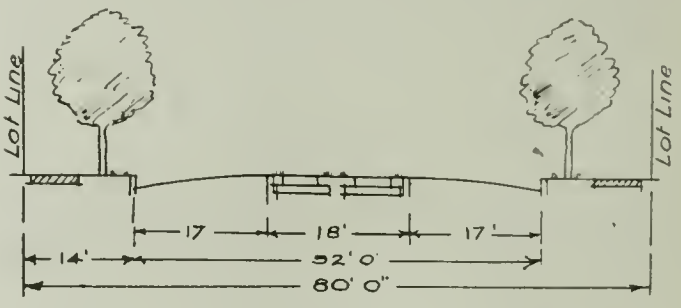


Fig. 8.

150 feet; (5) pleasure boulevards without parkways, 75 to 150 feet; (6) pleasure boulevards with parkways, 150 to 500 feet; (7) local business streets, 80 to 100 feet; (8) residential thoroughfares, 80 to 100 feet; (9) residential local streets, 50 to 80 feet; (10) wholesale and warehouse local streets, 60 to 80 feet; (11) alleyways, 10 to 20 feet; (12) residential and business lanes, 5 to 25 feet respectively.

In conclusion, the general functions of streets are threefold: (1) They act as thoroughfares; (2) as a means of access for property fronting on them, and (3) as open spalls for the admission of light and air to buildings. Therefore, the width must be mainly governed by the traffic requirements and the size of buildings.

Mussens Limited, of Montreal, have removed from 318 St. James Street, Montreal, and are now occupying their new offices on the 2nd floor of the McGill Building, 211 McGill Street, Montreal.

Plans for what is expected to be the tallest building in the world—57 stories—to cost $15,000,000, and capable of accommodating 10,000 people, have just been prepared by a Detroit architect for the Exhedra Corporation. Options have been obtained on a $5,000,000 site, bounded by Michigan and Cass Avenues, Lafayette Boulevard and First and Abbott Streets, Detroit, and tentative tenders have been called for. The plans call for a 27-story hotel and 57 stories of offices, running up into a tower 808 feet high.

COMPLETION OF A TRANSCONTINENTAL LINE OF PRECISE LEVELS.

By F. B. Reid,
Supervisor of Levelling, Geodetic Survey of Canada.

THE driving of the last spike in a transcontinental line of railway has usually been marked by some sort of ceremony on the part of the builders. No formalities took place, however, in connection with the last "shot" on the Geodetic Survey's first complete line of precise levels from the Atlantic to the Pacific. This was taken at Port Arthur, Ont., on October 17th last and closed a gap of about 300 miles which had existed at the beginning of the season; a similar gap of about the same length had been closed only a few days before in British Columbia. The finishing of the above links gives an unbroken line from the automatic tide gauge at Halifax to the automatic tide gauge at Vancouver.

Doubtless the first question to arise in the reader's mind will be as to the agreement obtained between the instrumental levels and mean sea level at the respective coasts. This enquiry cannot be answered offhand for the reason that for about 40 per cent. of the distance two or more lines of levelling have been completed, and circuits have thus been formed which give different elevations to the junction points, depending upon which route is used. Some fifteen circuits occur directly along the transcontinental line, not counting a number of others lying at a greater or less distance from it.

The system of levels is not sufficiently advanced to justify making an adjustment to determine the most probable elevations by utilizing the various circuits; it has, therefore, been deemed the fairest way to carry the elevations along from coast to coast by using the shortest route in every case where there is a choice of routes. The shortest line may in some cases be the first one levelled and in other cases the last. This, however, is not a matter of importance, as the same methods have been followed throughout the work, and consequently the same "weight" may be assigned to all the levelling. In this respect the work of the Geodetic Survey of Canada, having all been done within comparatively recent years, differs from some of the other countries in which the geodetic levelling is composed of work done by methods differing one from another.

Starting with an elevation of zero for mean sea level at Halifax as determined by the officials of the Tidal and Current Survey, Department of the Naval Service, and carrying along the elevations continuously by the most direct route, the level of the Pacific ocean at Vancouver is found to be 1.17 feet. Supposing mean sea level to be the same on the two coasts, this difference may be set down to errors in the levelling. Since some 60 per cent. of the line has not been duplicated by a second line it may be that additional levelling will disclose errors that will increase this amount, or, on the other hand, will reduce it. However, as all levelling has been done twice (independently forward and backward), and, as a number of checks have been obtained by means of water transfers on the Great Lakes and by connections at several points with the levels of the United States Coast and Geodetic Survey, it seems reasonable to assume that there will not be any very large change.

An article by the writer in *The Canadian Engineer* of April 20th and 27th, 1916, described in detail the territory covered, the datum planes used, and the methods employed by the Geodetic Survey in the extension of precise levelling. The fact was brought out that the levelling had been based upon three intermediate points besides the two coastal stations—Halifax and Vancouver—two of these points having been determined by the United States Survey. Publications have been issued by us each year for several years past giving the direct instrumental elevations along the lines in all five districts. It may be noted that the greatest difference at any bench-mark between the published elevation and the new "short-line" elevation is no greater than the above-mentioned closing error of 1.17 feet.

A word as to the route followed by this line, which, with the exception of two or three short jumps across country, lies along the railways for its whole distance. Starting at Halifax, the route of the Dominion Atlantic Railway is followed to Truro, thence the Canadian Government railways through Moncton and Edmundston,

Last Sight Being Taken at Port Arthur, October 17th, 1916.

N.G., and to a point about 95 miles west. From here we go across country to St. Philippe-de-Neri, Que., on the Intercolonial, and follow this and the Grand Trunk through Levis and Richmond to St. Hyacinthe. A combination of C.P.R. and G.T.R. lines then carries us along—south of Montreal and Ottawa—through Farnham, St. Johns, Lacolle and Coteau, Que., and Smith's Falls, Ont., till we reach Arnprior. The route is then by G.T.R. to Parry Sound, Ont., C.P.R. to Sault Ste. Marie and Algoma Central Railway to Franz—the junction with the C.P.R. main line. The latter is then followed to Port Arthur and the C.N.R. to Emerson, Man. From this point we go across country a few miles to Gretna, Man., and then follow the C.P.R. to Kamloops, B.C., the line chosen passing through Estevan, Moose Jaw, Lethbridge and Calgary. From Kamloops the C.N.R. is followed to within a short distance of Vancouver and the balance of the line lies along the Great Northern Railway.

The length of the route selected is a little over 4,000 miles, all of which lies in Canada with the exception of about 44 miles, for which distance the C.N.R. between Port Arthur and Emerson passes through the State of Minnesota.

Publications giving precise elevations of bench-marks, etc., on many of the above and other lines are available for distribution for the asking.

The combined population of the municipalities now served by the Ontario-Hydro Electric Commission through the medium of its various systems is 1,137,795.

HOW CAN THE ENGINEER IMPROVE HIS PUBLIC STANDING?

By F. W. Hanna,
Consulting Engineer, United States Reclamation Service, Ankeny, Iowa.

THE engineer's standing (or lack of standing) in the public mind and in public affairs is due to (*a*) the nature of engineering work, (*b*) the public's method of valuing men, and (*c*) the character of the engineer's education. The first of these causes is not susceptible of such changes as will materially affect the engineer's public status, but the second and third are not so strictly limited.

The remoteness of the benefit to be derived from a piece of engineering work makes its importance indistinct to the public vision. The design of a bridge is so far removed from its use in traffic that the public seldom connects the engineer with commerce and human travel; the survey of a reservoir site is not vividly enough related to the growing of crops on an irrigation project or the use of water from a faucet in the house to make vivid in the mind of a public the usefulness of the engineer. Neither does the hazy concept of the part taken by the engineer in these enterprises permit the public to appreciate the amount of intelligence and labor devoted to the design and the survey.

These illustrations are typical of practically all engineering operations. The engineer is assumed to evolve railroads, power developments and irrigation projects as an ordinary, easy natural process. His unseen mathematical calculations pass with the public as rapid addition at best, and his field work is mere ability to run a compass. The insight is little deeper than the public's knowledge of its tangible experience. This phase of the nature of engineering work is worthy of consideration, however, as the engineer must cope with it, and he should do it understandingly.

The public method of human valuation is generally imperfect, because its conclusions are usually drawn from a partial knowledge of the facts. Its facilities, time and ability for securing complete premises for conclusions are limited. The public necessarily consists of a mixture of individuals with varying mental dimensions and varying education, all intensely employed in their own affairs. The public seldom searches deeply for facts, and it is impressed on the average only by obvious truth. This is why all reforms are so painfully slow in realization and is also why the services of the engineer to humanity are little understood and poorly appreciated. The engineer's only remedy for this trouble is to get the facts before the public so that they will be obvious to it, through the use of the press, the school, the rostrum and literature.

The school, the press, the public rostrum and literature are the main sources of public information outside of the experience in the daily routine of life. The public is ready to read entertaining newspaper accounts of engineering works, and the scenes of a play or the plot of a novel can well be centered about some great piece of engineering work. Few engineers can succeed in writing plays or novels; and were they to do so they would turn their talents in that direction, as did Robert Louis Stevenson and F. Hopkinson Smith. The engineer, however, may endeavor to interest writers intelligently in the human as well as the material side of his work, and he may also improve opportunities to lecture on engineering and related subjects with resulting benefit.

Faced by such a literary and oratorical program, the engineer will often shrink rightfully from objection to self-advertisement, but wrongfully from fear of commercialization of his profession. Moreover, he generally feels incompetent to carry out his part in such a program, from lack of college training along certain lines. This indicates where some changes in our college engineering courses would be helpful.

The engineer on leaving college is not well-balanced educationally. He is well equipped to grapple with the laws of nature, but not with those of human nature. He has been trained thoroughly, and rightly so, in all the natural, rational, pure and applied sciences, but generally he has only a smattering of English, supplemented with a like smattering of German or French or Spanish. He knows but little psychology, political economy and sociology, but little law, too little of anything, in fact, that gives him an insight into human affairs outside of his own profession.

The college courses are only partly to blame for this state of affairs. The engineering student almost always sees his chosen profession too narrowly and avoids and slights the broadening subjects in his course of study. He conceives his profession to be that of converting the raw materials and potent forces of nature into human use, without seeing the necessary intervening and important conversion of his fellow beings into supporters of his projects. After some years of experience he learns that the latter is one of the big factors in his profession and then wishes that he could understand human nature and speak and write better.

The study of French or German or Spanish has a fine theoretical basis for its future utility in the engineering profession. A few of our engineers read engineering literature directly in these foreign languages, but most of us soon forget how to read them and depend on translations for our foreign information. A few of our engineers go into foreign lands and use directly the foreign languages learned in college, but the great mass of them find employment in their own country. Consequently, the large majority of engineers receive practically no other benefit from the study of foreign languages than that of general culture.

On the other hand, this large majority would receive the same mental culture and also an immense practical benefit through the substitution of a more thorough study of the English language and its literature. Let the engineer have enough rhetoric to make his tongue and pen certain of their ground, enough debating and oratorical work to induce a natural flow of speech while standing before an audience, and enough literature to loosen his poetical imagination and awaken his interest in the higher relations of mankind. He will then be better fitted to take his proper place in public affairs.

An intimate acquaintance in college with the fundamental laws of the human mind and with those of human society would be of profound service to the engineer in his dealings with the public. An understanding of these laws is just as essential to successful dealings with the public as is an understanding of the laws of inanimate nature and mathematics to the efficient handling of the material problems of engineering.

Due to his college training in mathematics, physics, mechanics, chemistry and the like, the young engineer readily and quickly manages problems involving their use. Occasionally an engineer has acquired an understanding of these fundamentals in his busy life of practice, but he was handicapped for their lack during several of the most useful years of his life. The engineer graduate

now suffers a similar handicap in his knowledge of the human mind, human society, human institutions. He is compelled to buffet against the world for a long time before he is equipped to handle a position involving serious dealings with the public. While more liberal college training in psychology, sociology, and political economy would not eliminate all of this buffeting, it would greatly lessen the length and severity of the apprenticeship.

The engineer's analytic habit of mind, his accuracy of thought and his honesty of purpose are excellent qualities for men in public service; but greater endeavor on the part of the engineer to secure public appreciation and better preparation of engineer graduates in their college work for public service will aid greatly in enlarging the engineer's share of appointments and elections to positions of public authority and influence.

GENERAL PAVING PRINCIPLES.

At the January meeting of the American Society of Civil Engineers, the "Committee on Materials for Road Construction and on Standards for Their Test and Use" presented a progress report, which consisted chiefly of a statement of the fundamental principles on which specifications covering each of the several types of roads and pavements should be based. As a preliminary to the discussion of the several types, it presented certain general principles which, although more or less elementary and fundamental, are often found to be neglected by those engaged in roadway work. These we have somewhat condensed in the following:—

Lines and Grades.—Choice of the material, or methods of using a particular material, may be affected by the grades as fixed. Certain materials, or results of using materials, for highway surfacings will be unsatisfactory outside of certain limits of grades. Conservative practice has fixed the maximum limits for satisfactory results with grades, as follows:—

Kind of Roadway.	Maximum Grade Per Cent.
Gravel	12.0
Broken stone	12.0
Bituminous surface	6.0
Bituminous macadam	8.0
Bituminous concrete	8.0
Sheet-asphalt	5.0
Cement-concrete	8.0
Brick (cement grout filler)	6.0
Brick (bituminous filler)	12.0
Stone block (cement grout filler)	9.0
Stone block (bituminous filler)	15.0
Wood block	4.0

Width.—Where motor traffic forms a considerable proportion of the total traffic likely to use a highway, the unit width of traffic lines to be considered is 9 or 10 ft. instead of 7 or 8 ft. as heretofore, because of the greater clearance required for the safe passing of the units of such traffic.

Where bituminous pavements are laid, the edges need protection and a sudden transition from the pavement to any softer shoulder material should be avoided by means of extra width, or of cement-concrete or other edges, and such reinforcement of the shoulder material as may be necessary.

The width of roadways of rigid material, such as cement-concrete or vitrified block, should be at least equal to what would be prescribed under local conditions for a less rigid surfacing. The great difference between the firmness of a rigid roadway surfacing and of material frequently available for the shoulders thereto, often makes it necessary, for safety and convenience of traffic, as well as for economy of maintenance, that the rigid surfacing should be built wider than would answer for a more flexible surfacing, such as water-bound macadam, for instance, under the same local conditions.

Too narrow a width of roadway encourages, if it does not compel, concentration of traffic to such an extent as to make frequently unfair demands on what would otherwise be a suitable and efficient material for the surfacing. This may be especially noticeable at abrupt changes in the lines of the highway, where any tendency toward the improper concentration of traffic into too narrow areas should be avoided, as far as possible, by such adjustment or separation of lines, and adjustment of width, of crown, or of slope of the roadway surfacing, as will keep the strains of the surfacing material within reasonable limits for it.

Thickness.—The thickness of the pavement or surfacing, of course, will be dependent largely on its type, but it will also be affected by the presence or absence in the construction of an artificial foundation, and, in fact, on the character and ability of the base on which the surfacing is to rest. Approved practice establishes the limits given in Table I. for the extremes of thickness for the various layers of the pavement or road crust.

Table I.

Kind of roadway.	Thickness of artificial foundation,* in inches.	Thickness of sand cushion or binder course, in inches.	Thickness of wearing course, in inches.
Gravel	4 to 8	.....	2 to 4
Broken stone	3 to 8	.....	2 to 3
Bituminous surface	4 to 8	.....	¼ to ½
Bituminous macadam	3 to 8	.....	2 to 3
Bituminous concrete.	3 to 8	.....	1½ to 3
Sheet-asphalt	5 to 8	1 to 1½	1½ to 2
Cement concrete (one-course)	.....	.....	5 to 8
Cement concrete (two-course)	4 to 8	.....	2
Brick	4 to 8	¾ to 1½	3 to 4
Stone block	5 to 12	1 to 2	2½ to 5
Wood block	5 to 8	½	3½ to 4

*Not including extraordinary provisions such as V-drains or sub-base courses.

Although the general practice has been too often perhaps to use mass, for the sake of safety, in the preparation of the pavement, it now appears to be evident that some waste has been incurred in the past in this direction, and that a more scientific determination of the thickness, as well as of many other features of highway work, is possible, without sacrifice of safety and yet with economy. However, in view of the recent, constant, and rapid increase of the weight of, and consequently of the strains caused by, the traffic, it will be in the interests of economy for designs of highways to be made with proper consideration of further increases.

Drainage.—The use of any form of pavement or road crust, whether bituminous or non-bituminous, does not relieve the necessity of proper drainage in every case. It is not only necessary to provide for such under-drainage as will place and keep the sub-grade in a condition satisfactorily free from moisture and in a state of suitable efficiency, but it is also necessary to provide and to preserve economically such provisions for surface drainage as will, with the provisions of under-drainage, insure these results fairly permanently. Storm-water coming to the roadway must be carried quickly and rapidly away from it by automatic arrangements to the natural watercourses, where it can be disposed of finally. The arrangements referred to and so made, such as inlets, ditches, gutters, and culverts, should be designed and placed so as to give the least possible offence to the users of the roadway and the abuttors, and yet be built so as to preserve their integrity and efficiency with the least need for attention and expense under even the most persistently adverse natural conditions. A proper longitudinal grade for ditches and gutters is particularly important, in order that the ill and wide effects of standing water may be avoided. A proper cross-section for ditches is also important, in order that the waterway may not become obstructed by the sliding in of the sides.

As related to drainage, the matter of the crown of the roadway is particularly important. The ideal roadway surface would be flat in cross-section were it not for the necessity of the automatic removal of surface water to the channels where it must be most conveniently carried along. Crowning the roadway tends to concentrate the traffic on the ridge where it is then most comfortable for the travellers, and the amount of crown which will result in this concentration on the ridge varies with the type of pavements. Also, the rate of crown necessary for the proper removal of storm-water to the gutters or ditches varies with the type, and with the provisions to be made for the cleaning and the upkeep of the roadway surface. In the general practice, the amount of crown for the shoulders of an uncurbed roadway has usually been a cross-slope of one inch per foot, the shoulders being of the natural earthy material, and this rate is to be recommended for shoulders, except in special cases.

The crown generally used in the construction of broken stone roadways is excessive when bituminous materials are used, and a crown of even one-half inch per foot should be avoided when a lesser crown can be secured without detriment to the surface drainage.

For the various roadway surfacings, the practice generally observed and to be recommended is as given in Table II.

Table II.

Kind of roadway.	——Crown Recommended—— Maximum.	Minimum.
Gravel	1 in. to the ft.	½ in. to the ft.
Broken stone	¾ " " " "	½ " " " "
Bituminous surface	½ " " " "	¼ " " " "
Bituminous macadam	½ " " " "	¼ " " " "
Bituminous concrete	½ " " " "	¼ " " " "
Sheet-asphalt	¼ " " " "	⅛ " " " "
Cement-concrete	⅜ " " " "	¼ " " " "
Brick	⅜ " " " "	⅛ " " " "
Stone block	½ " " " "	¼ " " " "
Wood block	¼ " " " "	⅛ " " " "

Concave pavements of cement-concrete, vitrified block, or stone block may frequently be found advantageous for alleys, and, in such cases, the same rates of slopes in cross-section as those previously given should govern.

Artificial Foundations.—Where the character of the traffic justifies the use of an artificial surfacing, it also demands a correspondingly strong foundation. Whether or not an artificial foundation shall be supplied will depend on the local conditions, but in the selection of the materials and the methods of construction of the artificial foundation, every consideration should first be given to the possibilities for securing the greatest efficiency from the natural foundation. Economy in reference to the roadway will be had from the proper choice of the various materials available for artificial foundations, such as sand, gravel, broken stone, and concrete.

In the construction of a concrete foundation, the subgrade should first be properly prepared and its greatest efficiency developed. The thickness of the cement-concrete artificial foundation usually laid is 5 or 6 inches, but it may be varied advantageously according to the local conditions between 4 and 12 inches. The thickness may be varied sometimes between the centre of the roadway and the sides.

The most usual proportions for a cement-concrete foundation have been one part cement, three parts fine aggregate, and six parts coarse aggregate. This standard, however, is empirical rather than scientific, and a more rational proportion in any case should be developed according to the needs and facilities of each case. It may often be desirable to increase the mass in some cases at the expense of unit strength, or to increase the mass for the sake of economy in the more expensive material.

Subgrade.—The use of any form of pavement or road crust does not relieve the necessity for the construction of a well-drained, thoroughly compacted, homogeneous, and stable subgrade in every case. Indeed, such improvement of the highway generally attracts heavier traffic and thus increases the stresses on the subgrade. Even when an artificial foundation is to be constructed on the subgrade, proper attention should be given to the preparation of the latter, in order that the greatest economy may be had in the design and expense for the artificial foundation, and, generally speaking at least, the higher the type and the more expensive the artificial foundation, the greater care should be exercised to develop to the utmost the possibilities of the subgrade. Uniformity in its composition and compaction, as well as evenness of its surface, is far more important than has apparently been generally considered necessary up to this time, and permanence of all the desirable qualities in the subgrade is equally important.

Joints.—For the ordinary joints in block pavements, the materials and methods of filling should be selected so as to produce not only a surface which will retain to the utmost its imperviousness and the stability of the blocks themselves in place, but also as far as practicable they should conduce toward evenness of wear of the surface of the pavement. If the blocks are resistant to abrasion, but perhaps inclined to round off at the edges of the upper surface under traffic, such filling of the joints is desirable as will lend additional resistance in the blocks to this rounding off at the joints.

A bituminous filler may be preferred to a cement-grout filler, on account of the lower cost of street-opening repairs, the better foothold provided for horses, and the securing of a more resilient and hence less noisy pavement. On steep grades, where some roughness of surface

may be desirable for the sake of affording better foothold for animals, some openness at the top of the joint is desirable, and the bituminous joint fillers may be preferred. With bituminous joint fillers, care must be taken to select materials which will not be too brittle in cold weather and so chip out from joints under traffic, and which will not be so soft in hot weather as to flow out of the joints between the blocks. It is believed, although not yet generally admitted as having been actually proven by experience, that the use of a bituminous mastic for joint filling would be an improvement over the customary practice of using bituminous material alone for this purpose. Great care should be taken with bituminous fillers of any kind to insure the actual filling of the joints between the blocks, and great care must be taken to insure this result.

Shoulders and Gutters.—Where rigid or fairly rigid pavements are laid, their edges should be protected and the sudden transition from such a pavement to any softer shoulder material avoided by means of edges or such reinforcement of the shoulder material as may be necessary. The line or strip of contact between a cement-concrete roadway and the flanking material of the shoulders being the zone of weakness under traffic, it is important to accommodate the traffic and to protect the roadway as well as the shoulders from the formation of ruts along this line. This is especially true when the roadway is so narrow as to result in the frequent passage of vehicles from the pavement to the shoulders.

Such material for and construction of the shoulders should be had as will result in their being capable of efficient and economical maintenance under the local conditions existing or likely to prevail.

The shoulders may be reinforced with paving, concrete, macadam, gravel, or similar surfacings; or they may be of the natural local material available, due consideration being given to the advisability of tapering down from a relatively high rigidity of the roadway itself to any soft natural material at the outside edges of the road.

Finishing of Surface.—An objectionable slipperiness of many pavements may be decreased or prevented by proper precautions during construction or by proper treatment thereafter. The length of time that a finished pavement should be closed to traffic in order to season properly before use varies from a few hours to several days, dependent on the character of the material and methods used and on climatic and other local conditions. Pavements in which Portland cement is used for filling the joints or in the mass of the surfacing itself should seldom, if ever, be closed for less than two weeks after completion.

The committee consists of W. W. Crosby, chairman; H. K. Bishop, A. H. Blanchard, secretary; A. W. Dean, N. P. Lewis, C. J. Tilden and G. W. Tillson.

RAILROAD EARNINGS.

The following are the weekly earnings of Canada's transcontinental lines during March:—

Canadian Pacific Railway.

	1917.	1916.	Inc. or dec.
March 7	$2,442,000	$2,198,000	+ $244,000

Grand Trunk Railway.

March 7	$1,063,190	$ 992,026	+ $ 71,164

Canadian Northern Railway.

March 7	$ 669,100	$ 540,200	+ $128,900

PROPOSED EXTENSION OF WATERWORKS AND SEWERAGE SYSTEMS AT TRAIL, B.C.

HEREWITH is presented a summary of reports submitted to the corporation of the city of Trail, B.C., by A. L. McCulloch, consulting engineer, Nelson, B.C., for the proposed extension to the waterworks and for the proposed sewerage system.

Waterworks.—The present system was constructed by a private company in the early days of the city's growth. It was bought by the municipality in 1910, the supply being by gravity from a small mountain stream, supplemented by an additional supply through a 4-inch pipe from the smelter water supply, the latter being, however, only intended as an emergency supply.

On account, however, of the rapid growth of the city in the last two or three years, the present supply is not satisfactory, even for domestic supply, and is totally inadequate for efficient fire protection.

The present population of the city is estimated at 4,000. There has been an increase of 40 per cent. in the school population of the city during the last 12 months, and in all probability there will be a large increase in population during the next 12 months.

It is therefore essential that something should be done at once to secure an adequate water supply and to build larger mains for adequate fire protection.

Available Supplies.—To get the amount of water required with an assurance of a reasonable supply for the future growth of the city the following sources could be utilized:—

(1) By gravity from Cambridge Creek, supplemented by the storage and use of water from Violin Lake.

(2) By pumping water from the Columbia River.

(3) By a gravity supply from Blueberry Creek, distant 17 miles from the city. This supply, on account of the cost, could only be developed in conjunction with the Consolidated Mining and Smelting Co., who also need to supplement their present gravity supply.

All the other streams in the neighborhood of the city, including Rock, Stoney, Murphy and Trail Creeks, are utilized as a water supply to the smelter.

Of the three available supplies, that from Cambridge Creek is easily the best and cheapest to develop.

In December there was a flow in Cambridge Creek of 630,000 gallons per day, while the flow from Violin Lake was 260,000 gallons per day, a total of 890,000 gallons per day, with an estimated extreme low-water flow of 600,000 gallons.

By utilizing the storage possibilities of Violin Lake this available daily supply can be increased to over 1,500,000 gallons per day.

Violin Lake is at an elevation of 1,850 feet above the business portion of the city. It is a long, narrow lake, being about one mile long, and has a surface area of 50 acres; it has a depth of 60 feet, the depth at 25 feet out from the proposed point of diversion being 9 feet.

Between Violin Lake and Cambridge Creek there is a ridge or divide 23 feet above the level of the water in the lake, the distance being 2,650 feet to get to a point on Cambridge Creek at the level of the lake.

This divide presents obstacles to utilizing Violin Lake to supplement the flow from Cambridge Creek.

It is feasible to conduct the water over this ridge by a syphon, which, however, may require almost daily attention, and on account of the remoteness from the city (about 7 miles) should only be resorted to if a gravity flow conduit is impracticable, which it is not.

Mr. McCulloch is of the opinion that the most economical method of diverting this water is to raise the level of the lake permanently 10 feet and lay a 14-inch tile conduit through the ridge at a depth of 13 feet. It is proposed to construct an earth dam at the outlet of the lake to a height of 25 feet, with suitable sluiceway and spillway, and utilizing the lake for storage purposes between elevations 10 and 20 feet; the cost of the development at the lake to be $11,000.

From the diversion weir on Cambridge Creek the water will be conducted by a pipe line 8,400 feet long with a daily capacity of 1,500,000 to a 1,000,000-gallon distribution reservoir at the city limits, at an elevation of 375 feet above the business portion of the city. This elevation is necessary in order to give suitable pressure to the higher portions of the city, the pressure on the lower or business portion being reduced by the use of pressure regulator valves on the supply mains to any desired pressure.

Distribution System.—The new mains to consist of 1,950 feet of 10-inch pipe, 6,420 feet of 8-inch pipe, and 9,000 feet of 6-inch pipe. There will be 14 new hydrants, 28 new gate valves and 2 pressure regulator valves.

In the new system under ordinary conditions the engineer favors the use of steel pipe throughout, but on account of the present abnormally high price of steel pipe (the present factory prices being 75 per cent. higher than in January, 1914, 87 per cent. higher than in 1915, and 70 per cent. higher than in January, 1916) puts a somewhat different complexion on the matter and it is felt that the merits of steel and wood pipe would have to be considered under present conditions.

It is almost impossible to get deliveries from the shops, within any reasonable limit, and the steel pipe that is used will have to be purchased from the stock held by dealers.

Wood-stave pipe is favored for the conduit pipe line from Cambridge Creek to the reservoir. This is also true of the 10-inch main from the reservoir, and in the 8-inch supply main along the bench to the corner of Spokane and Green Streets, a distance of 4,450 feet, being approximately 200 feet above the business or main portion of the town.

The estimated cost of the proposed waterworks system is $60,000.

Sewerage System.—On account of the ease with which surface water can be handled, due to the topography and the natural drainage into the Columbia River and Trail and Gorge Creeks, which run through the city, it is not proposed now to provide for surface water in the sewers to be constructed.

A modification of the separate system of sewers is recommended,—one that takes care of all sewage proper and provides for the roof water as well.

It is proposed to empty the sewage into the Columbia River, which at Trail has an extreme low-water flow of 14,000 cubic feet per second.

On account of the scarcity of labor and the consequent high wages, the recommendation is made that the whole of the pipe be laid in one contract, so as to make it worth while for a contractor to come in with a suitable plant, the material to be excavated being very suitable for trench excavating machines.

It is proposed to construct 22,100 feet of sewers. The main sewer, being 15-inch and 12-inch, will be 1,650 feet long, while the laterals, amounting to 20,450 feet, will be 8-inch and 6-inch, the latter on steep grades on short branch sewers.

The probable cost of the proposed system will be $40,000.

A by-law is to be submitted to the ratepayers as soon as the proposed source of supply is approved by the Provincial Board of Health.

ADDITION TO STANDARD UNDERGROUND CABLE PLANT AT HAMILTON.

In preparation for the prosperous times which the company anticipates will prevail after the close of the war, the Standard Underground Cable Company of Canada, Limited, is making an addition to its factory at Hamilton, Ont., which, when completed and equipped with the necessary machinery, will represent an investment of $50,000. The new structure will consist of one story, with basement built of brick and concrete, and will be 125 by 120 feet, giving a total increase in floor space of 30,000 square feet. Ample fire protection apparatus is also provided for, which includes a complete automatic sprinkler system.

The new building will be devoted exclusively to the uses of the wire-drawing department, and in addition to housing the former equipment will contain material additions of new machinery of the latest design capable of drawing wires ranging in size from No. 40, B. & S. C., which is about the thickness of a hair, to the largest size of trolley wire; also machines for grooving trolley wire and for rolling flats and squares, such as are used in the manufacture of magnet wire. There will also be two new "Bright-annealing" furnaces for annealing or softening the wire after it has been drawn. This addition will not only give room for a considerable increase in the output of the wire-drawing department, but the space released will allow for expansions in the stranding and cabling departments.

All of the machinery in the new plant will be electrically operated by three-phase alternating current motors of 550 volts, 25 cycles, the current being furnished by the Hamilton Hydro-Electric Department and carried from the overhead transmission lines of the department to the transformers on the company's property by underground cables. Power is now taken for other uses in the plant from the Dominion Power and Transmission Company. The architects are Prack and Perrine, of Hamilton.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended March 9th, 1917:—

Trethewey Silver Mines, 37,297; Hudson Bay Mine, 65,382; Kerr Lake Mining Company, 86,619; Coniagas Mine, 78,689; La Rose Mine, 87,424; Dominion Reduction Company, 149,000. Total, 504,411 pounds, or 252.2 tons.

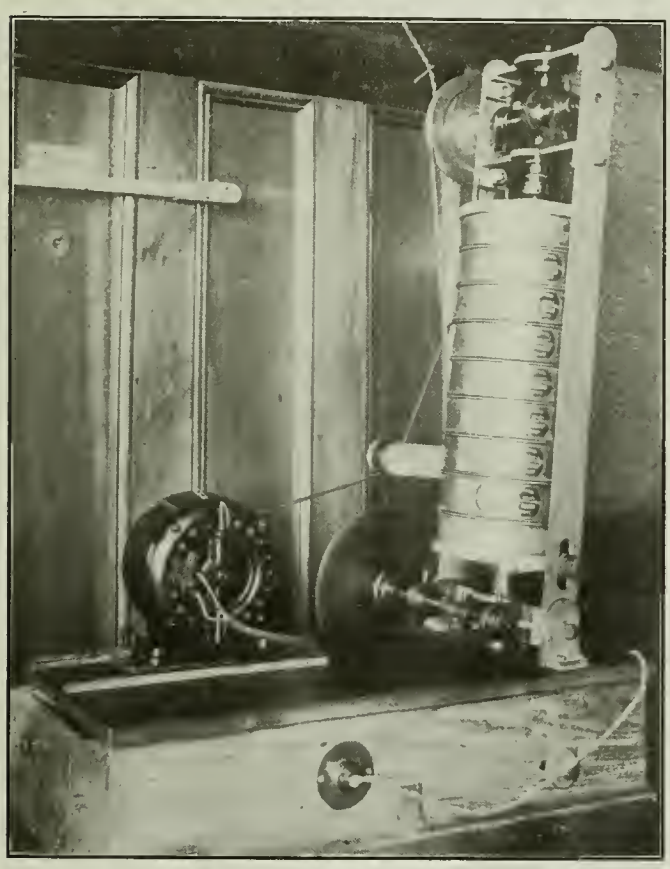
The total shipments since January 1st, 1917, now amount to 4,289,973 pounds, or 2,144.9 tons.

An illustrated address was given on March 14th, at the Shaughnessy Building, by Mr. George M. Berry, chief chemist of the Holcomb Steel Company, of Syracuse, N.Y., and inventor of the process by which hydro-electric power has been commercially applied to metallurgy. The lecture was arranged by Arthur D. Little, Limited, under the auspices of the Canadian Pacific Railway, with a view to showing what could be done to use undeveloped water powers in Canada to develop other industries, and especially the electrical making of high grade steel.

A NEW SAND SIEVING MACHINE.

THE accompanying illustration is of a recently developed sieving machine that is a part of the equipment in the Montreal paving laboratory of the Milton Hersey Company, where it is used for making the screen analyses of sands for asphalt pavement, concrete work and other similar tests. There are but two other machines like it, the original model at McGill University and one other that was specially built for a large mining and smelting company.

This machine is so constructed that it may be readily and accurately adjusted to the requirements of different classes of material. The inclination of the sieves may be set to suit the work in hand, the weight of the tap or blow may be governed, and the speed of the revolutions and number of blows may be changed by using different sized pulleys or a motor with different speed.



Bell Sand Sieving Machine.

The standard adjustment, however, is the result of much very careful experimenting on the part of Professor Bell, who sought and found the combination of movements that would with the least wear and tear and in the shortest period of time furnish results that would be sufficiently uniform for scientific purposes.

In operation the nest of sieves is forced down by a cam on the horizontal shaft above against a spring in the base of the machine. When the cam releases the sieves they are forced upward by the spring through a distance of about one-tenth of an inch, and in being brought to a sudden stop the grains of material on the sieve cloths are thrown upward in a manner tending to clear the apertures. The force of the spring-blow may be adjusted as desired, but an eighteen-pound pressure has been found to be satisfactory. The distance of the upward throw of the sieves can be also adjusted.

A satisfactory adjustment for general purposes was found to be four hundred taps per minute while the sieves were revolving at the rate of two and one-half full turns per minute. The rate of rotation of the sieves in conjunction with their inclination distributes the material over the screen cloths by causing the grains to reach the highest point and then slide down again. They journey in a more or less elliptical path. The best inclination for each class of material would slightly vary, as for coarse sand and hydraulic cement, for instance, but for practical purposes a satisfactory compromise is easily determined.

So far, no move has been made to manufacture this machine on a commercial basis. It was developed for use in connection with some very important investigations in which it was found that other machines did not give sufficiently accurate results. It is the invention of Mr. John W. Bell, M.Sc., assistant professor of mining engineering at McGill University, Montreal.

WATER SUPPLY OF MOOSE JAW, SASK.

Mr. Geo. D. Mackie, city commissioner of Moose Jaw, Sask., has recently issued a report dealing with the water supply of that city, from which the following abstract has been taken:—

In any waterworks, whether public or private, the yearly expenses which have to be provided for may be included under the following heads:

1. Interest on bonded debt.
2. Yearly payment into sinking fund.
3. Yearly payment into depreciation fund.
4. Yearly operating and maintenance expenses.

All of these payments, if the waterworks plant is to be run on a proper basis, must be met fully year by year out of the annual income.

The functions performed by a waterworks plant are:

1. To furnish water for private use.
2. To furnish water for public use, such as street sprinkling, sewer flushing, supply to public buildings, etc.
3. To furnish fire protection to property.

The sources of revenue of a waterworks department are derived from: 1st, the water rates, and 2nd, the funds received by general taxation. The former are paid by those who use the water, and the latter by assessment. The cost of furnishing water to private consumers should be paid by water rates on the basis of the quantity of water used. The cost of supplying water for public purposes should be paid by taxation according to the amount of water used, and the cost of fire protection should also be met by taxation, since the individual is benefited by reason of the protection afforded to property. As all water mains are generally laid of a size larger than is required for present purposes, the cost of providing for the future should also be met by taxation on the city as a whole.

From observations which have been made by waterworks engineers all over the continent, it has been found that from 30 to 50 per cent. of the total expense plus the cost of water used for public purposes, should be met by general taxation, and the remainder of the revenue obtained from the water sold.

In arriving at the rate which should be charged the property owner whose land abuts on a water main, the rate should be equitable in regard to the benefit which accrues to the property so situated. The city imposes a

frontage tax of from six to seven cents per foot for sewers, and a rate of ten cents per foot, in my opinion, would be equitable in the case of water mains. The frontage assessment for water in a number of cities is as under;

Regina	7	cents per lin. ft. of frontage per annum
Winnipeg ..	4	" " " "
Edmonton ..	10	" " " "
Calgary	10	" " " "
		(on unimproved property)
Calgary	5	" " " "
		(on improved property)

There is a doubt whether a frontage tax can be levied on property where mains have already been laid, but it has been done in the case of Regina.

The minimum charge for water in Moose Jaw for domestic purposes at present is $1.50 per quarter by way of a fixed charge, and $1.50 per quarter for water, making a total minimum charge per quarter of $3, or $12 per annum. If it were decided to raise the charge for water for domestic purposes so as to increase the revenue by fully $31,000 on the present basis of consumption, and leave the fixed charges as at present, the minimum rates would be:

Fixed charge per quarter	$1.50
Minimum charge for water per quarter	$3.00

or a total of $4.50 per quarter, or $18 per annum. The effect of this charge would be that the price of water for domestic purposes would be raised from 40 cents per 1,000 gallons to 80 cents per 1,000 gallons, and from a statement which I have already supplied you with, showing a comparison of the rates charged by different waterworks in the three prairie provinces, this new rate would make the rate charged by the city of Moose Jaw the most expensive of any of the waterworks in the provinces, with the exception of the town of Yorkton, where the rate charged is 80 cents per 1,000 gallons.

Statement of Waterworks Revenue and Expenditure for Various Cities for the Year 1915.

	Moose Jaw.	Regina.	Saskatoon.	Winnipeg.
		— Revenue —		
Commercial ...	$51,435.36	$137,733.36	$66,854.69	$486,704.93
Departmental ...	3,889.90		6,662.90	24,994.57
Fire department.	10,623.33		14,000.00	69,060.00
Miscellaneous ...				3,850.28
	$ 65,948.59	$137,733.36	$87,517.59	$584,609.78
		— Expenditure —		
Operating	$45,699.62	$ 49,822.88	$54,025.31	$234,322.57
Sinking fund....	20,485.51		8,961.52	102,097.00
Interest	64,203.85	103,841.62	15,279.93	273,865.58
Miscellaneous ...				760.81
	130,388.98	153,664.50	78,266.76	611,045.96
Deficit	$64,440.39	$15,931.14		$26,436.17
Frontage taxes		27,652.04	(?)	73,730.16
Surplus		$11,720,90	*$9,250.83	$47,293.98

*The balance of interest and sinking fund payments on the capital expenditure of the waterworks, which is $1,132,424.51, is met by frontage assessment, the amount of which is not known.

	Moose Jaw.	Regina.	Saskatoon.	Winnipeg.
Population	16,889	26,105	21,054	163,000
Cost of plant	$ 817,000	$ 650,000	$ 281,574	$4,121,191
Cost of distribution system	536,000	670,000	1,003,342	2,205,777
Total cost of plant	$1,353,000	$1,320,000	$1,284,916	$6,326,968
Cost per capita	$80.11	$50.56	$61.02	$38.81
Number of services	2,000	4,039	2,284	32,108
Average daily consumption (in gallons)	718,492	2,193,026	1,140,827	8,000,000
Daily consumption per service	359.24	542.96	499.48	249.15
Daily consumption per capita	42.54	84.00	54.18	49.07
Revenue (commercial and departmental)	$55,325.26	$116,233.36	$73,517.59	$511,699.50
Revenue per 1,000 gallons	.21c.	.14c.	.17c.	.17c.
Revenue per service	$27.66	$28.77	$32.18	$15.93
Revenue per capita	$3.27	$4.45	$3.48	$3.13
Expenditure	$130,388.98	$153,664.50	*$78,266.76	$611,045.96
Expenditure per 1,000 gallons	.49c.	.19c.	*.18c.	.20c.
Expenditure per service	$65.19	$38.04	*$34.26	$19.03
Expenditure per capita	$7.72	$5.88	*$3.71	$3.74
Number of hydrants	303	430	452	2,072
Charge per hydrant	$35	$50	$30	$33
Mileage of water mains	68	55	44	250
Lineal feet water main per service	179.5	71.9	101.7	42.75
Lineal feet water main per capita	21.24	11.1	11.0	8.4

*The total expenditure in the case of Saskatoon cannot be shown as the amount levied for interest and sinking fund payments by way of frontage tax is not given separately in Saskatoon's financial statement.

NOTE—The figures in these tables are from the 1915 financial statements of the respective cities, or from the publication "Waterworks and Sewerage Systems of Canada," by the Commission of Conservation, Canada.

Editorial

THE ENGINEER AND HIS PUBLIC STANDING.

Much has been said recently as to the place of the engineer in the community, and rightly so. It seems to be very difficult for the general public to recognize the importance which attaches to the work of the engineer. Yet if the hand and brain of the engineer were to be taken away only for a week, virtually all the activities of the modern world would be paralyzed. But few seemingly give the matter a passing thought. The foundry, machine shop, draughting room, etc., and the equipment and mentality with which they work, are the underpinning and keystone of the present era.

Sanitation is bound up with public health, transportation with the question of food; water supply, printing, practically every service making for efficiency and convenience, together with every article of use, owes its present state to the work of the engineer.

In view of this, is it not entirely justifiable and, in fact, only proper that the engineer should assert himself as a factor in the community? It is safe to state without qualification that to the engineering section of the community the remainder of the people are in everlasting debt.

To the engineer himself who possesses imagination, a liner on her passage, an express train at full speed, a bridge spanning hundreds of feet, inspire a reverent feeling. While aware that they are common enough features, he realizes their magnitude and all the effort needed for their design and operation. The public, on the other hand, does not concern itself much with these things. Its valuation is superficial.

Only in the measure that the engineer asserts himself by means of the newspaper press, the school, the platform and literature, as is so clearly brought out in an article by F. W. Hanna on page 256 in this issue, will the engineer ever occupy his rightful place.

It is safe to assert that the administrative capacity in his possession is so general that his hand might safely guide and control in a more general sense.

The first step, however, is recognition. The community at large must understand that though generally silent, he is able and experienced in complex problems affecting quantities of men no less than in those dealing with quantities of materials. He may not be able to split hairs, not being trained in legal casuistry, but where practical administration is concerned, he should continue to find wider and greater opportunities than ever.

ORGANIZATION FOR HIGHWAY WORK.

While organization for the carrying on of highway work is only a means to an end, yet without proper organization neither construction nor maintenance can be carried on with the maximum of efficiency and economy.

The organizing of their forces is one of the real problems of those who are responsible for the construction and maintenance of roads. While there may be individual members of the working force who possess unusual skill, the results are bound to fall short of the ideal unless these various skilled units are welded together and made to do efficient team work through the assistance of organization.

Different conditions call for different forms of organization and no hard and fast rules can very well be laid down which will fit into all situations. There are, however, certain well-defined principles which are applicable in almost every case. Of these, perhaps the most important is that of delegating to each subordinate sufficient authority to enable him to produce the result for which he is personally held responsible.

Of course, it goes without saying that an organization cannot be efficient which does not have as the responsible head, an executive upon whom is imposed the task of securing certain definite results. Under him should be other executives upon whom are imposed certain duties along the line of general rules, but to handle the details without interference. Right here is where more otherwise model organizations have come to grief than through any other one cause, for men cannot and will not do their best work if there is any danger of interference.

If an organization is to continue and do its best work this principle of non-interference cannot be too carefully watched.

WORK OF JOINT COMMITTEE OF TECHNICAL SOCIETIES.

The Joint Committees of Technical Societies, embracing representatives of all the engineering societies in Canada, are meeting regularly in Toronto and in other centres.

The membership represented by these committees embraces about 10,000 engineers in Canada.

Each society is in touch with its members and each and every member is requested to send to their representatives suggestions of a practical nature that may tend to help the Canadian forces in the field or aid in solving the many problems now before us or likely to arise because of the war.

It is the one ambition of these technical men to serve. Many of them are too old to go to the front and many others, through the important positions they occupy, are doing better service here in Canada than they could perform in other spheres of usefulness.

While the Joint Committee is devoting a great deal of time to the work already allotted to them, they will be glad to take up any new work that appeals to them as within their scope, if any of the members will send them ideas along that line.

Inventions that will aid any branch of the service will be confidentially investigated and worked up by practical men, and if likely to be of service will, with the consent of the inventor, be forwarded to the proper authority for test and acceptance.

Suggestions for aiding recruiting for the engineering corps, employment of returned soldiers, research work connected with war materials or for processes of national importance will be taken up so far as facilities permit.

Correspondence on any of these subjects requiring technical advice or reports, should be sent direct to the

secretary of the Joint Committee of Technical Organizations, Ontario Branch, Excelsior Life Building, Toronto, and will be acknowledged promptly.

The annual meeting will be held in the Chemistry and Mining Building, Toronto University, Toronto, the evening of March 30th, and will be addressed by Mr. John Murphy, chief electrical engineer of the Department of Railways and Canals; Mr. Matheson, late of Colorado but now chief engineer of the British American Nickel Corporation, and others. All engineers, whether members of any society or not, will be privileged to attend this meeting.

PRELIMINARY STATEMENT OF THE MINERAL PRODUCTION IN THE PROVINCE OF QUEBEC FOR 1916.

The first compilation of the mineral production of the province of Quebec during 1916 shows a total value of $13,070,566. As compared with the previous year, $11,465,873, this is an increase of $1,604,693, or 14%.

The mineral production is roughly divided into "products of the mine" and "building materials," and analysis of figures shows that the increase is wholly attributable to the former, which show an increase of 52.8%, whereas the building materials have decreased 18.5%. In 1915 the figures were: Produce of the mines, $5,223,639, or 46%; building materials, $6,242,234, or 54%. In 1916, produce of the mines, $7,982,430, or 61%; building materials, $5,088,136, or 39%.

This advance is very gratifying, especially when it is taken into consideration that the building materials, comprising limestone, granite, cement, lime, brick and other clay products represent a large proportion of the mineral production of the province.

The following table presents the total figures of the mineral production of the province for each year for the last 17 years:—

Year.	Value.	Year.	Value.
1900	$ 2,546,076	1909	$ 5,552,062
1901	2,997,731	1910	7,323,281
1902	2,985,463	1911	8,679,786
1903	2,772,762	1912	11,187,110
1904	3,023,568	1913	13,119,811
1905	3,750,300	1914	11,732,783
1906	5,019,932	1915	11,465,873
1907	5,391,368	1916	13,070,566
1908	5,458,998		

ANNUAL DINNER OF ENGINEERS' CLUB OF TORONTO.

The annual club dinner of the Engineers' Club of Toronto will be held Friday, March 23rd. The result of the balloting in connection with new club quarters will be announced. A musical programme has been provided and a large attendance of members is earnestly requested.

ENGINEERS' CLUB, PETERBOROUGH.

A well-attended dinner, given by the civil, mechanical and electrical engineers who are interested in forming an Engineers' Club, was held recently at the Oriental Hotel, Peterborough, Ont. The officers elected were: President, C. E. Canfield; secretary, G. R. Langley.

PERSONAL.

ARTHUR J. SMITH, building contractor, Brandon, Man., has enlisted for active service.

W. F. TYE, M.Can.Soc.C.E., of Montreal, has been engaged by the Hamilton city council to prepare a report on a common entrance for all railways into Hamilton.

A. E. FOREMAN, A.M.Can.Soc.C.E., formerly assistant city engineer of Victoria, B.C., has been appointed chief engineer of the department of public works of British Columbia.

ANSON J. HOPKINS, who has been with the Canadian Fairbanks-Morse Co., Limited, in Vancouver, was recently appointed general head of the accessory department of that company, and is now organizing the work of this department in the firm's eleven branches.

HENRY W. FISHER, chief electrical engineer, Standard Underground Cable Co., Perth Amboy, N.J., gave an illustrated address on March 16th before the Toronto Section of the American Institute of Electrical Engineers on "Underground Cables: Their Manufacture and Use Under Modern Practice."

R. O. WYNNE-ROBERTS, M.Can.Soc.C.E., Toronto, has become associated with Mr. Frank Barber in connection with the York Township water scheme and other works, and will conduct his practice as consulting engineer at 57 Adelaide Street East, Toronto, until the end of this month, when new premises will be taken.

OBITUARY.

GEORGE FOREST McKAY, of New Glasgow, N.S., who assisted in the founding of the Nova Scotia Steel & Coal Co., and who was the oldest director of the company, died on March 13th at the age of 82 years.

Lieutenant C. R. NEEDS, A.M.Can.Soc.C.E., civil engineer of the Canadian Aviation Corps, was killed in an aeroplane accident in England, February 27th. Lieut. Needs was resident engineer of the C.N.R. until the outbreak of war, when he went to Galt as chief inspector of the munitions plants there for the Canadian Inspection Co.

During the fiscal year ending June 30th, 1916, the city of Detroit laid 259,671 lin. ft., or 49.18 miles, of water mains.

The total expense for operating and maintenance of the water softening and purification works of the city of Columbus, O., for 1916 was $199,299, of which $24,902 was for labor and supervision, $168,346 for chemicals and $6,051 for general supplies. The cost of purification per 1,000,000 gal. delivered to consumers was $27.75.

According to a recent issue of a Buenos Aires paper, new steel works have been established at Santiago, utilizing the scrap iron which was previously exported to Europe. This new enterprise owes its existence to the high price of steel. Much difficulty was experienced at first in obtaining skilled workmen, but the situation was saved by the employment of Spaniards from Bilbao. It was necessary to set up a special plant for the manufacture of the machinery required, which is of European type. Chilean coal is used as fuel. The products of the new steel plant include merchant bars, sheets, angles, bars for reinforced concrete, nails, horseshoes, tires, etc. The price of Chilean steel is 20 per cent. less than that of the imported article. The quality may be considered as medium. The output of the new works is disposed of without any difficulty.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

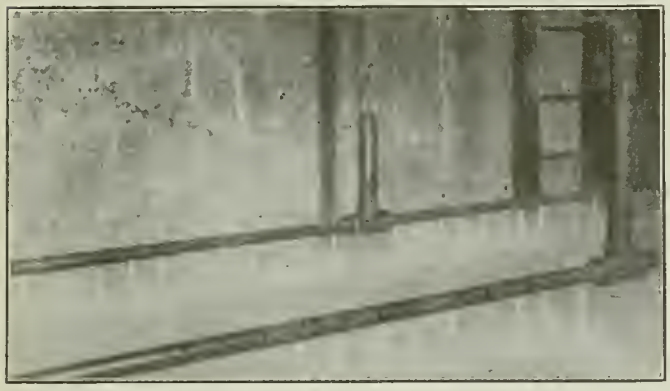
ACTIVATED SLUDGE PLANT AT EDMONTON

DETAILS OF AERATING CHAMBER, MOTOR EQUIPMENT, AND AIR PLANT —ACCOUNT OF EXPERIMENTAL WORK BEING DONE IN WESTERN CITY

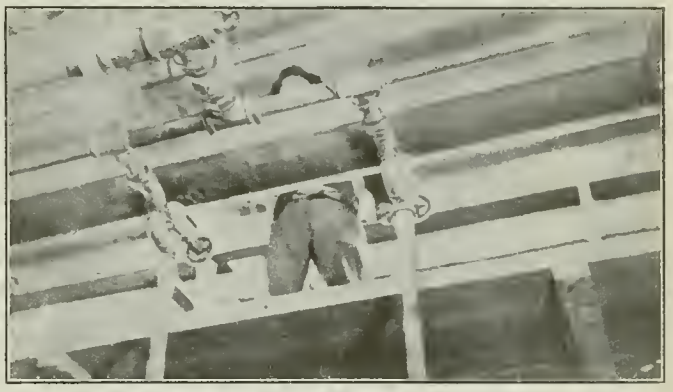
THE following facts concerning the experimental work being done at Edmonton, Alta., in connection with the activated sludge process of sewage disposal are taken from a pamphlet on the subject recently issued by Geo. T. Hammond, engineer in charge of the Sewage Experimental Station, Brooklyn, N.Y.

The plant at Edmonton was designed about two years ago when little was known about the activated sludge process, and as the plant was not solely for experimental purposes the precaution was taken of building an Imhoff tank alongside of the aerating tanks.

The following data concerning what is known in Edmonton as the Ross Flats sewage disposal plant were furnished by Mr. A. W. Haddow, acting city engineer, and used in the pamphlet referred to.



Showing Flush-water Passing Through Apertures in Bottom of Air Supply Grid.



Showing Connections at Top of Air Pipes.

The system is combined and has a contributing area of 294 acres with a population of 4,500. The dry-weather flow averages 33,600 cubic feet per day.

The maximum storm flow to be treated is 54,000 cu. ft. per day, equal to 75 Imperial gallons per head of population. The balance will overflow into the North Saskatchewan River through the present outlet. The nature of the sewage is non-septic with very little trade waste. All contributing sewage has to be pumped and enters the pump well through a cage for rough screening. This cage can be lifted to the floor level of the pump-house when it is necessary to be cleaned. There is no suction lift, and the maximum force lift from the bottom of the well to the baffling chamber is 45 ft. The pumping equipment consists of one 4-inch single-stage, vertical spindle, centrifugal pump, electrically driven, and automatically controlled by a float. Capacity under trial was 60 cu. ft. per minute pumping against an average head of 42 ft. plus friction. One duplicate pump complete in all respects is held ready for emergency service.

The motor equipment consists of one 11-h.p. motor directly connected to each pump. The power consumed is 4 kw. per hour, which equals 1⅓ kw.-hour per 1,000 cu. ft. pumped.

The aerating chambers, which were originally designed for live earth beds, number six. The fill-and-draw principle is used, but changes could easily be made by which the continuous-flow principle could be used. The length of these chambers is 44 ft. with a width of 10 ft. and a depth of 8 ft. The depth of sludge is about 2 ft. and capacity of each 3,420 cu. ft. The working capacity above sludge is 2,500 cu. ft.

The Imhoff tank referred to was originally designed at a suitable elevation to take effluent from what are now the aerating tanks. It is now being used for independent experiments and takes part of the raw sewage direct from the grit chamber. It could take effluent or sludge from aerating tanks if it was ever decided to try such an experiment. At present the effluent goes direct to the river. This Imhoff tank has a total depth of 21 ft. The capacity of the flowing-through chamber is 3,780 cu. ft., while the capacity of digestion chamber is 6,340 cu. ft.

The Air Plant and Air Distribution.—For this there is used one Connersville high-pressure blower, size No. 31. The capacity of this blower against a working pressure of 3½ pounds through a 4-inch discharge is as follows: Low speed (255 r.p.m.), 180 cu. ft. of free air per minute; high speed (330 r.p.m.), 240 cu. ft. of free air per minute. The maximum may be increased later by altering the belt drive. The blower has capacity to spare for the one tank in operation, but a blower of a larger size will be ordered if all the tanks are fitted up for aeration, when the present blower will act as a spare. The air-main along the centre of the tanks has been started off at 10-inch diameter in view of this. This 10-inch main is of cast iron, as we find it best for tapping

and making tight connections for the down pipes. The tank under experiment has four 1½-inch down pipes, with a valve and a Dart union below the valve on each pipe. They are placed at 30-inch centres and branch into two 1-inch pipes at the bottom of the tank, one running towards each end, where they are plugged. Each down pipe with its two branches is an independent unit, and by unscrewing the Dart union, it can be lifted for examination without interfering with the blowing on the other three pipes. The two branches are supported from channel-irons by means of six ⅜-inch hollow rods (pipe) which, by means of a thread and nut give a slow-motion control of the air pipe. We find that after the air pipes have been set dead level that we have both to raise and to lower them by means of this nut to obtain perfect air distribution. We cannot give any reason for this. The air pipes have ⅛-inch holes drilled on the under side at 3-inch centres. We find this gives better distribution than drilling on the top or on the sides. So far the resulting air distribution is excellent. However, no sludge is yet accumulated, but we have taken precautions to obviate trouble from this source. Each down pipe is connected below the valve and above the Dart union to a branch from a 3-inch high-pressure water main (100 lbs. per sq. in.) for flushing purposes. These four water branches are controlled by a single valve. In addition, the water can be shut off by a main valve, and steam admitted through the same piping. Provision is made for expansion on this account. Then, as already stated, each air-line can be lifted independently and cleaned if the water and steam are not sufficient. A check valve is introduced on the main air feed near the blower to prevent water getting into the blower in case of carelessness in operating the valves.

Activating Tank Showing Air Supply Grid.

General.—The whole plant is housed in on account of the low temperatures experienced in winter; 10 to 20 degrees below zero is not uncommon, and we sometimes have it as low as 40 degrees below zero, usually at night. The machinery hall at least will have to be heated in winter, and we are inclined to think that this will prove a considerable added expense, on top of others necessitated by the aerating process. The North Saskatchewan River, into which all our sewage discharges, has a dry-weather flow of about 1,000 cu. ft. per second, and is rich in free oxygen. In summer the flow is very much larger.

The United States Consul at Barcelona states that careful estimates place the quantity of unmined iron ore in Spain at 700,000,000 tons, with an average content of about 50 per cent. of metal.

CONSTRUCTION AND MAINTENANCE OF CATCH BASINS.

SOME few weeks ago a discussion on the subject of catch basins, their construction and maintennnce, took place before the Sanitary Section of the Boston Society of Civil Engineers. The discussion was opened by Mr. George A. Carpenter, city engineer of Pawtucket, R.I.

Mr. Carpenter's introductory paper dealt largely with the method of cleaning catch basins. For several years he endeavored to discover some form of basin construction that would lend itself to better and more economical cleaning methods, or some more satisfactory way of cleaning the type of basin already in use. About four years ago employees of Pawtucket developed the idea of a power hoist on an automobile truck for lifting the material from catch basins. This has been improved upon, and the contrivance now used consists of a Standard chassis with a 32-horse-power engine, carrying a steel body, 9 feet by 4¼ by 2⅓ feet high. Cover plates two feet wide are placed over each end to prevent the load slopping out. The capacity is 3.4 cubic yards, and the average load carried has measured about 2.6 cubic yards and weighed about 3.4 tons. The tail board is hinged at the top to facilitate dumping and is provided with a rubber gasket so that it can be clamped tight against the body. Dumping is effected by a hydraulic lift.

Back of the driver's seat are mounted two 6-inch "I" beams, and on these is a 2-horse-power Fairbanks-Morse gasoline engine, cable drum and control mechanism. The cable runs to an outrigger, which can be swung over the catch basin and back over the cart. (The 2 horse-power engine is to be changed to a 4-horse-power, as the former is found lacking in power for the heaviest work.)

The bucket first used was a plain cylindrical one, 14 inches in diameter and 17 inches deep, and was filled by hand by a man in the basin. Since November, 1913, an orange-peel bucket has been used. This was operated by oil under a pressure of about 100 pounds per square inch, but recent experiments have indicated that by using compressed air in place of oil the time of loading can be materially reduced. Under the old method of cleaning basins, before the truck was used, the average time of loading was 40 minutes per cubic yard and the average time of hauling 3,500 feet was 35 minutes. When the truck was first put in operation with a bucket loaded by hand, the average output was 13 cubic yards per day of nine hours, which was increased to 23.4 cubic yards per day; and experiments with compressed air indicate that this can be increased to 31.2 cubic yards. In hauling the load, the truck has averaged eight miles or more per hour. Mr. Carpenter believes that with air in use the city will be able to average 2.6 cubic yards every 45 minutes delivered to a dump 1¼ miles distant, or an average hourly output of 3.455 cubic yards. Allowing interest at 4 per cent. on the cost of the truck ($4,200), with depreciation and repairs at 20 per cent. and a new set of rear tires every year and of front tires every two years, with labor at $12 a week, gives a cost per cubic yard of 75 cents, as compared to $1.80 under the old method.

As to the form of catch basin, the one used in Pawtucket has its bottom half practically the same as that used in most of the other cities, consisting of a circular well with a concrete or stone slab bottom, the well being

4½ to 5 feet in diameter and from 4 to 5 feet deep below the outlet. Practically all of the cities use some sort of trap over the outlet, the object of which is apparently more to keep sticks and other floating matters out of the sewer than to prevent the entrance of sewer gas; although the latter is considered, and in some cases special provision made for it. The Coleman trap was used in Pawtucket some years ago, but Mr. Carpenter finds that the inlet is small and so constructed that small sticks, leaves and other floating matter readily enter and often produce a complete stoppage; and when frozen slush enters a basin in winter, this form of trap is easily clogged and difficult to relieve. These objectionable features were partially overcome by the addition of a galvanized iron hood over the opening to the trap. Finally, the trap was removed and the hood alone used in the later manholes, the hood being made of cast-iron. Some basins have been constructed and have been in use for years without giving trouble, in which a regular "S" trap is placed just outside the basin, the inlet being protected with a cast-iron hood.

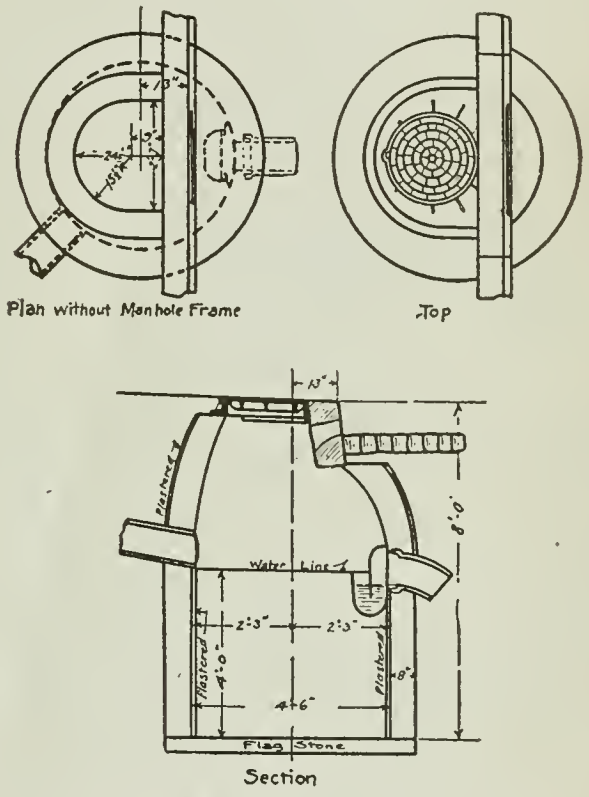
Still another device used in Pawtucket was building the lower part of the basin of two concentric rings of brick, with a 2-inch space between them, and the inner ring built of soft, porous bricks. A pipe leading to the sewer was carried through the bottom of the outer ring, thus draining the space between the rings, and causing a partial drying of the dirt in the basin, the moisture from which passes through the inner ring of brick.

Concerning the top of the basin, Mr. Carpenter believed that great improvement has been made by substituting cast-iron for the heavy stone tops used a few years ago. The heavy granite head was very expensive, and occupied a considerable space in the sidewalk, whereas, with the cast-iron head now adopted in Providence and a number of the other cities, nothing but a light iron cover about two feet in diameter shows on the surface of the sidewalk. Another improvement is in the location of the basin. Instead of placing these at the intersection of the curb lines, the basin is located above the cross walk on one street, and an additional inlet or chute is located on the other street above the other cross walk and connected with the basin. Where corner basins already exist, the old entrance to the basin can be closed and two plain inlets be constructed, one on each street, connected to the old basin.

"When planning catch basin openings and connections, the speaker has often felt the lack of sufficient data relative to the approximate amount of storm water that will pass a given opening in the curb, and also the maximum quantity that will pass the form or trap and connection used. Inlets through the curb, of the form illustrated, generally measure about 4 inches by 24 inches, 4 inches by 30 inches, or 4 inches by 36 inches, as the location seems to demand. Eight-inch, 10-inch or 12-inch pipes are used for connections between the basin and the sewer, as the engineer's judgment dictates. The speaker raises the question, Would it not be well to have more definite data than we at present possess respecting the relative capacity of various inlet openings, traps and sewer connections? Investigations along this line might be made with profit?"

Mr. Carpenter does not use or like the gutter inlet, but prefers the curb opening. He finds among other things that the gutter inlet is very apt to become clogged with leaves, stones and other matter from the streets. Most of the New England cities referred to in the discussion, however, seem to make more or less extensive use of the gutter inlet.

In Cambridge the "D" frame and grate are used, with the straight side of the "D" against the curb. The Cambridge frame and grate weigh about 65 pounds and cost about 12.50 per set. They find that these are liable to clog in time of storm, for which reason a slot or throat is cut in the face of the curb, back of the grate. The trap used is a cast-iron hood which can be lifted up for cleaning out the pipe, the entire trap costing about $5, and including a metal valve that opens outward toward the sewer to shut out sewer gas in case the water falls below the hood. One unusual feature of the Cambridge basin is the size of the outlet pipes, which were built some years ago of 10-inch pipe, then of 8-inch, and 6-inch pipe is now being used, and City



Details of Catch Basins as used in Providence, R.I.

Engineer Hastings states that he has never heard of one of these being stopped up on account of its small size. As stated above, although there are 2,260 basins in the city, the number of cleanings last year was only 1,128, and these averaged 2.1 cubic yards per cleaning, which is about the capacity of the catch basin. The cost of cleaning was $6.48 per basin, or $3 per cubic yard. This cost has increased during the past ten years from $2.58 per basin, or $1.44 per cubic yard, while the number of cleanings has decreased from 2,340 to 1,128.

Boston, although claiming to have invented the "D" grate, has abandoned it for square grates, principally for the reason that they are much easier to pave against. Boston last year cleaned 9,907 basins, removing from each basin about 3¾ cubic yards. The cleaning is done by contract at cost of $3.01 per basin. As the basins are five feet in diameter and four feet six inches from the bottom to the level of the outlet, it is seen that in this case also the basin is in every case nearly full of dirt when it is cleaned. In fact, it is doubtful whether

a basin of this size could be made to contain more than 3½ cubic yards and still permit it to carry off any street water. Since 3¼ was the average contents of the basins cleaned, it would appear that all of them, before cleaning, had reached this condition of limit of capacity, and it would, therefore, seem quite probable that in the case of many of them, they had ceased altogether to serve as catch basins some time before being cleaned.

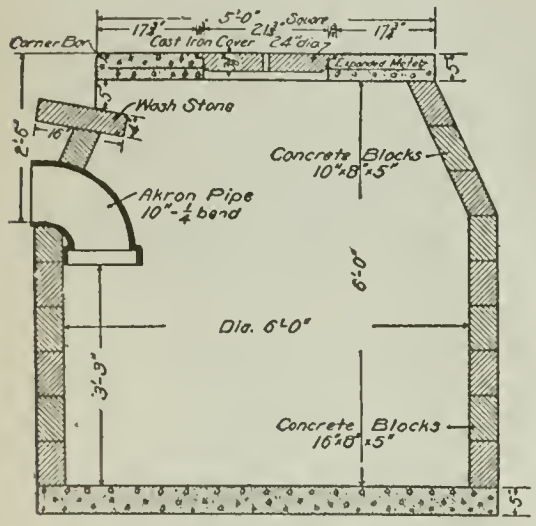
In the Boston parks it has been specified at times that the contractors may have the choice of using either brick or concrete in constructing basins, and they have usually chosen to use brick.

In Boston they had tried to find some form of mechanical cleaner, but had not discovered any which was practicable. There, and in Cambridge as well, they had tried a suction device known as the Otterson auto eductor. This device was described by Philip W. Taylor, who stated that it was an invention of George W. Otterson, of Seattle, Wash., and consists of a centrifugal pump, sand eductor, dump body and the necessary fittings, all mounted on a Kelly Springfield motor truck. The dump body is a steel box nine feet long, six feet wide and three deep, and is divided into two chambers, one holding water for liquefying the dirt in the catch basin, the other for receiving the dirt so removed. The latter chamber is divided by vertical steel baffle plates, one foot less in width than the wagon body and staggered so that the water pumped from the basin must flow around the baffles as it advances to the back of the machine, the chamber thus acting as a sedimentation tank. These baffles are hung on horizontal pipes at the top of the body and are free to swing so that when the load is being dumped the material may slide under them. Between this settling chamber and the water chamber is a steel plate screen through which the water passes.

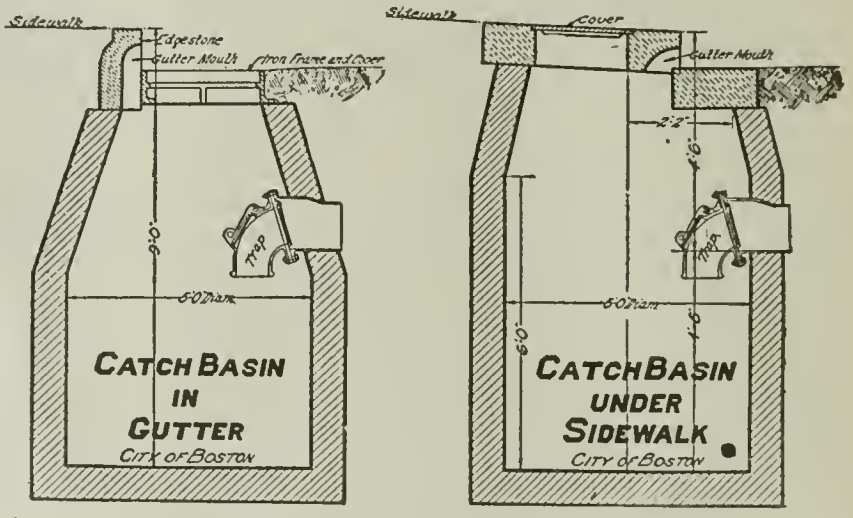
The eductor consists of an orifice and throat somewhat similar to a sand ejector. The tank having been filled with about 400 gallons of water, the truck is driven to a catch basin and the eductor let down into the basin. The pump forces this water through hose to and through the eductor. In passing through it sucks up the dirt from the basin, this dirt being made more or less liquid by discharging a part of the water through a pipe terminating in a nozzle which is operated to stir up and soften the material. The same water is used over and over again after depositing the dirt in the settling chamber. When the settling chamber is nearly full, the truck is driven to the dump and emptied. Mr. Taylor stated that the commissioner of public utilities of Portland, Ore., reported that in a test of 4½ hours' duration, 84 basins were cleaned, and that 137 basins were cleaned in an actual day's work of eight hours. The material removed from the 84 basins during the test totalled 13 cubic yards, or a little over 4 cubic yards per basin. In this connection it should be stated that "in the West the large curb openings are absent and all of the water passes through the grate openings, therefore the material is much easier to handle than in the East, where almost anything in size up to a football may be found." One criticism made by a city engineer of this and similar machines is that the entire working part of the machine is idle a large part of the day while going to and from the dump, and he suggested the advisability of having the pumping contrivance in a vehicle separated from the body or tank which receives the dirt, so that one excavating contrivance could be used with two or three dirt bodies.

In New Bedford, Mass., the type of basin which is being used at present is 6 feet inside diameter and 6 feet deep and is built up of concrete blocks 16 inches by 8 inches by 5 inches, which are manufactured by the city, the last three courses being built with specially bevelled blocks to reduce the size to 5 feet diameter. (See Fig. 1). The top is covered with a reinforced concrete slab 5 inches thick and 5 feet square, made of one part cement, one and one half peastone and one and one-half sand, with the addition of about two quarts of hydrated lime to each bag of cement. In this city, the basins are cleaned on an average of twice a year, although some are cleaned more frequently than others. The cost of cleaning is about $2.50 each.

In Fitchburg, the basin outlet is usually 8-inch pipe placed 3 feet above the bottom, giving a storage capacity of about 2¼ cubic yards. Unless the basin discharges into a strictly storm sewer, a cast-iron trap is used consisting of a flap valve to prevent odors coming from the sewer and a hood to prevent sticks or other obstructions from getting under the flap valve. On account of the many hills in that city, it is necessary to bank the grates or build a dam on the lower side in order to conduct the water into the basin. This was not considered an ideal way, and a ribbed surface grate was designed, having



Concrete Block Catch Basins as used in New Bedford.



Two Styles of Catch Basins used in Boston.

bars running diagonally across the gutter, the back edge of each bar being ¼ of an inch lower than the front edge of the grate. This makes a saw-tooth surface that slows down the velocity of the water and diverts it partially through the gully opening and partially down through the grate. This grate clogs with paper, leaves, sticks, etc., as do all other grates; but even though clogged, it still in most cases diverts the water toward the gully opening. Three complete rounds of the catch basins are made by the cleaning gang each year, but some basins do not need to be cleaned oftener than once in two years, while others require cleaning five to eight times a year. During 1915, 1,279 basins were cleaned, an average of 2¼ cubic yards being removed from each basin. As it was stated that the total capacity of each basin was 2¼ cubic yards, it would appear that no basin is cleaned until it is full and probably overflowing. An investigation of the operation of cleaning during May and June, 1915, showed that the teams spend 45 per cent. of the total time hauling the material. As the location of available dumps recedes from the centre of the city as the latter builds up, the length of haul is increasing, and this time will continue to increase unless some more rapid method of transportation is adopted.

Concerning gutter grates, W. L. Vennard, city engineer of Lynn, Mass., said: "Basins as sometimes built without throats, do not take the water efficiently. The grate, at the beginning of a rainstorm, becomes covered with leaves and paper or other debris and the water passes over, while those that have the throat permit the water to enter through it and the swirl of water entering generally tends to keep the grate clearer from debris than when there is no throat." In Lynn the D grates are supplemented by a throat cut in the curb-stone. The basins are cleaned through the D grate in the gutter, there being no opening in the sidewalk.

ENGINEERS' CLUB, TORONTO, WILL MAKE ALTERATIONS—RESULT OF VOTE RE NEW CLUB QUARTERS.

The annual club dinner of the Engineers' Club of Toronto was held last Friday night, when between seventy and eighty members were present.

The result of the voting regarding new club quarters was announced.

One hundred and ten votes were cast for proposal No. 1, which was to move to the "World" Building. Twenty four votes were cast for proposition No. 2, that is, to stay in present quarters, not making any alterations. Proposal No. 3 secured five votes, while No. 4 received 118 votes. Under the plan the club will secure an additional 4,200 square feet of floor space, accommodation will be provided for five billiard tables as against three at present; the dining-room will also accommodate about 30 more members.

The total vote in favor of staying at the present address but with the changes made which will more adequately serve the purposes of the club, was 147 as against 110 in favor of moving.

The daily per capita consumption of water at Duluth, Minn., in 1916 was 81.86 gals. The cost of supplying the water, figured on operation, maintenance, depreciation and interest on bonds, was $86.31 per 1,000,000 gals.

COST ACCOUNTING FOR THE CONTRACTOR AND ITS RELATION TO HIS ORGANIZATION.*

By Leslie H. Allen.

A SYSTEM of cost accounting to be of any value to a contractor must be used. Its data must be accessible to and understood by everyone in his organization who has anything to do with costs. It is valueless if it is kept a secret.

A proper system of cost accounting may be likened to an expensive tool or machine—of great value when working, but an unjustifiable expense if kept idle most of the time.

Costs are Not Trade Secrets.—The contractor who thinks that his unit costs are a trade secret and that the circulation of information regarding his costs will do him an irreparable injury is making a great mistake. If his costs are higher than his competitors' they will lose business if they use them. If they are lower they will lose money if they use them. It is efficiency and not cost data that makes for low costs. The cost data simply point the way to efficiency and show the failures to reach it. For this reason my firm has not hesitated to make public its costs at any time. We feel that if we make lower costs than our competitors it is because we have the men and brains needed to do it. Others cannot equal our costs simply because they know them. On the other hand, if our costs are higher than they should be no one gets from their publication any valuable information that can give them an advantage over us.

Intelligent General Interest in Costs.—Very many contractors have the labor costs distributed by a timekeeper and worked up in his spare time by the bookkeeper, and the results are only seen by the boss. Neither man understands his work or can show any enthusiasm for it. The opposite of this is the case on our work, and it is sometimes quite embarrassing to the writer to be called upon to adjudicate in cases where knotty points are being discussed with great earnestness by our timekeepers and foremen, such as whether repairing forms damaged by the strippers should be charged to stripping, erecting, or making—or what to do with the saw filer. The fact that such interest is shown in minor points indicates a real interest in efficient work and low costs all down the line.

It is the purpose of this paper to show how use is made of the data furnished by a cost accounting system in the organization and supervision of the jobs and the carrying on of the general business of the contractor, and to demonstrate the vital necessity of up-to-date information on costs to the various departments of his organization.

The contractor's problem in any system of cost accounting is not to so conceal the costs that no one but the boss can get them or understand them, but to make them accessible to and understood by the greatest possible number of people in his organization. The more people he can educate to understand cost analysis in his organization, the more intelligently and sensibly is his work going to be handled. Not only this, but it is very desirable that the architect or engineer should have some idea as to the costs of the work being done by the contractor under his direction.

Immediate Value of Cuts.—There occur to my mind many incidents on our own construction work where the

*Abstract of a paper presented to the American Concrete Institute, February 8th, 1917.

engineer's knowledge of what our work was costing has led him to allow modifications in the design which have saved much money for our clients, whereas if our cost accounts had been concealed our suggestions and arguments regarding a change in the design would have gone unheeded. For instance, on a recent job where the depth of column footings varied, owing to bad ground, the engineer desired to build all footings the same thickness and to start all columns at the same height and to make up the different depths between top of footing and bottom of column by pyramids of concrete, each one of which, of course, would need separate forms of varying shapes. Instead of arguing on a matter of opinion we were able, after building two or three, to demonstrate that this method was much more expensive than putting additional concrete into the footings, and we were allowed to make the change.

Principal Features of Cost System.—First, the estimate: (*a*) An estimate for each job is made, based on the costs of earlier jobs of similar nature. (*b*) This estimate should be analyzed to show first the quantities, unit costs, and total costs of each item of labor, and then the quantities and estimated prices of each item of material and each sub-contract.

Second, a daily labor cost report showing the labor costs of each day's work.

Third, a weekly labor cost report showing in parallel columns the estimated and actual quantities, unit costs, and total costs of the work performed.

Fourth, a monthly statement of the cost of materials and sub-contracts purchased or ordered, showing in parallel columns estimated and actual costs.

Fifth, a final summary made at the close of the job showing the total cost of all labor and material.

Estimate of Cost.—In many offices the estimate is locked up in the safe the day the contract is signed, and never sees the light of day again. The estimate is, or should be, the result of the estimator's study of cost data on preceding jobs, and is therefore the standard set for the cost of the job for which it was made. With it daily labor costs and material purchases should be compared. It contains much valuable information that is most useful to, and should be made use of by, the contractor's force.

In order that it may be of the greatest possible use it should be in sufficient detail to show in separate items the various kinds and classes of work done by different gangs, and it is best to make an analysis of the estimate into two main divisions: Labor; Material (sub-contracts and all items not classed as labor). The total of the first division, therefore, gives the estimated total payroll and shows how it is expected that this will be spent upon carpenters, masons, laborers, etc. The second division shows in detail the quantities of material, sub-contract work, etc., item by item.

Use of Estimate.—Who should see and use this valuable information and work to these standards?

First, the general superintendent. It gives him standard of performance by which he can measure up his job superintendents and foremen. It tells him more in a few minutes about the supply of materials and sub-contracts than would a day's studying of the plans, and in general is a big help to him in supervising the employment, supply of materials, progress, etc.

Second, the job superintendent needs more than anyone to see the estimate. From it he can see what the firm expects him to accomplish in the way of costs and his criticisms of the estimate should prove helpful to the estimator. With it he can confer with the purchasing agent of the company and with the local dealers from whom he has to buy supplies and without a lot of computation on his part he can place the orders for much of his material. From the sub-divisions of the analysis he can determine the sort of organization that should be placed upon the work, how many carpenter foremen, how many carpenters, the size of the labor gang, the number of mechanics, etc. Reading the estimate will call to his mind all the work that has to be done.

The estimate shows him the quantities of materials he has to receive and he can plan for their efficient storage.

Third, the purchasing agent. From the material section he prepares a more detailed schedule and by taking dates from the progress schedule he can prepare for his own use a list showing all materials required and the dates required in order that he may start in buying intelligently and see that everything is delivered on time. He has a valuable check on the bids received.

Fourth, the scheduling men also should receive the material section of the estimate and check their quantities by it. From the purchasing agent they receive notice of the dates these schedules are required in order that he may buy them and have them delivered at the job in time.

Fifth, the foremen of brickmasons, carpenters, concrete gangs, etc., should be told what are the estimated costs of their work, and shown from week to week how their work compares with the estimates.

Daily Labor Costs.—The second important feature of a cost accounting system is a daily report of the labor costs. These are best prepared on the job and should be in the job superintendent's hands by 9 o'clock the next morning.

If each carpenter foreman is told what are the estimated costs on the operations he is to do and is notified every day as to whether he is coming inside or overrunning his costs, it is sure to have its effect. We frequently plot the principal items graphically on a chart which not only the carpenter foremen but the carpenters can see as they check in and out. The lowest laborer takes a cheerful and even enthusiastic interest in the vagaries of the wandering line that shows the cost of the work he is doing.

It is best to keep the cost accounts on the job instead of in the head office. Costs to be of any use should be fresh, not stale. If the superintendent knows at 9 o'clock the very next day that concrete costs 20c. a yard more to put in than on the preceding day he can talk it over with his foreman while the matter is fresh, and investigate and remedy the fault; but if the news does not come to him until a week or ten days after the work in question is done, it is too late to do anything.

The daily costs point out to the superintendent an occasional high spot that he has missed, and are an unfailing barometer of the job.

Weekly Labor Costs.—The fourth essential of a cost system is a weekly labor report. This should show in parallel columns the estimated and actual quantities, unit costs, total costs, and saving or overrun. This statement should be furnished to the heads of the main office of the company as well as to the job superintendent. By the use of a simple summary, the main facts can be condensed into a very few items. This statement gives a sort of review of the job's operations to date. It should go to the general superintendent and the estimator in the head office. The latter particularly needs to know the fluctuations in costs in order that he may check up his judgment with actual facts and learn the costs of any new sort of work.

ELECTROLYTIC CORROSION OF WATER PIPE.*

FRED B. NELSON: Tests and examinations have been recently made by the New York department of water supply on fifty meters which had been in continuous service for different periods of time, including five groups of ten each installed at five-year intervals from 1895 to 1915. It may be of interest as having a possible bearing on the subject of electrolysis that on the disc chambers of those installed in 1900 a decomposition or pitting of the bronze chambers was found which was not present in any marked degree on those installed in 1895 nor on subsequent installations. The appearance of the decomposed metal suggested electrolytic action, and analyses were made by the Central Testing Laboratory of the bronzes of the disc chambers affected and of one disc chamber not affected, from which the conclusion was drawn that the decomposition was due to a solution of the metal, the solution depending upon a number of factors, among which was the difference in composition or mechanical treatment and consequent differences of potential between adjacent portions of the meter.

The analyses showed quite marked differences of composition of the bronze, even between the two halves of the individual disc chambers, these differences being least in the analyses of the unaffected chamber. The analyses also seemed to show that the bronzes higher in zinc and lead were the most susceptible to the corrosion. Analyses of the water being used through these meters showed no chemical differences that would account for the difference in corrosion.

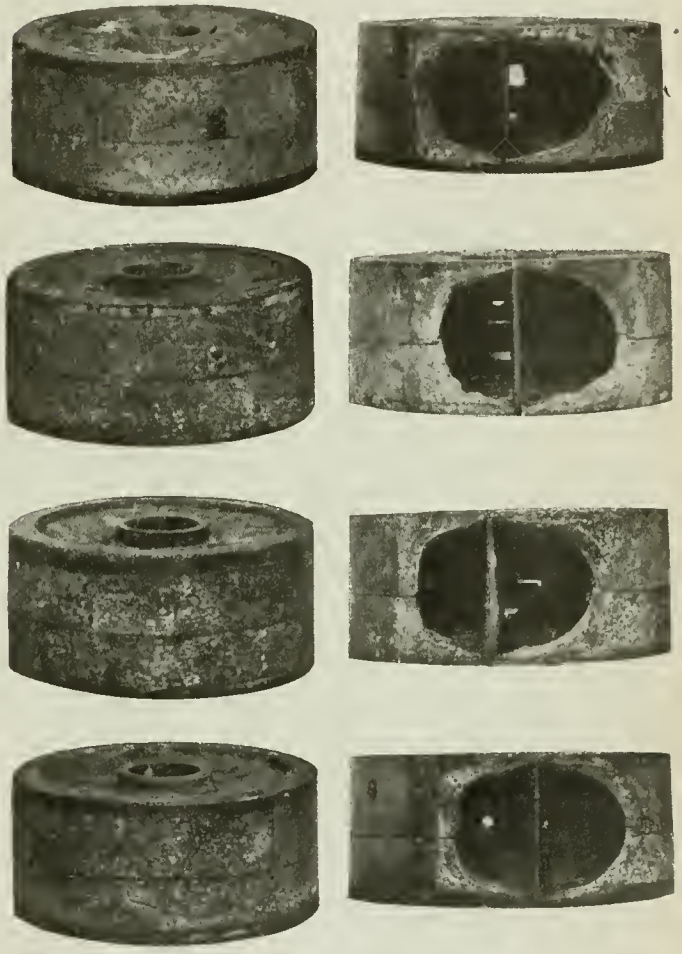
This case of corrosion of bronzes is not cited as an instance of the usual action of electrolysis, as no indication or instance could be found to indicate that any stray electric currents existed or were leaving the bronze at the affected portions. It does, however, seem to illustrate a somewhat similar decomposition of the metal that may be caused by local galvanic action due to differences in composition or treatment of the adjacent bronzes used.

The appearance of the corroded disc chambers is shown in the accompanying illustration.

H. B. Machen: A rather interesting case of what we believe was electrolysis recently appeared in the borough of The Bronx, New York City, where, as you know, the entire trolley system is of the single wire overhead type.

A leak was reported as at 132nd Street, near Lincoln Avenue. The department forces made the necessary excavations, exposing the pipe, and found that for a small portion of the pipe the iron had practically disappeared, leaving the carbon, the specific gravity of a section broken out about 6 inches square being about 2.

An examination was then made to determine if possible the cause of the local trouble and if possible prevent its recurrence. The pipe runs for about 800 feet through made ground, which at the point where the pipe was exposed consisted of a fair grade of earthfill. The trench was dry, although but 600 feet from tidewater. The nearest elevated railroad and trolley lines were about 400 feet in a straight line. There was no difference of potential between the pipe and elevated railway except when a train was passing, and but very slight at that time. No differences could be detected at any time between the pipe and the trolley road. Examination of the pipe, which had been tested to 150 pounds at the foundry where manufactured and had been in service for a number of years at approximately 35 pounds pressure, showed that the trouble was confined to one length only. The total area affected was about 4 square feet toward one end of the length, and indicated that the iron had been largely extracted, leaving carbon so soft that it marked paper easily. The pipe coating was in good condition in many places, having still the original gloss evident. To date it has not been possible to locate any source of current, either to or from the pipe, and still every fact



Appearance of Corroded Disc Chambers.

available after the break disclosed the weak spot points to electrolysis as its cause.

As an illustration, the reverse of the case mentioned above and located in the same borough might be cited; the 36-inch main on Jerome Avenue, where the pipe parallels a trolley line for over five miles. During a repair being made at night, just as the sleeve was being slipped over the end of the pipe, several sparks jumped the gap, which appeared from the bank to be about 1 inch, and which surely was over ½ inch. This certainly indicated that the pipe was carrying current, and still we have had no trouble appear from electrolysis, which can have been going on for twenty years.

D. F. Atkins: The department of water supply, gas and electricity of New York has received applications from electric railway companies for permission to bond their tracks to the water mains. This permission has been refused in every case, for there has been no proof offered that the city would gain anything by permitting

*A discussion of an informal address by Prof. Albert F. Ganz before the New York section of the American Works Association.

such bonding, whereas the railway companies would thereby be relieved in a measure of the necessity of bonding their tracks so as to form a proper return circuit, which they should provide.

Harry V. Allen: A water consumer in an outlying section of Brooklyn was required to pay a bill for water which was in part wasted on account of a leap in the pipe between the meter and the fixtures. The pipe had been corroded by electrolysis and he wished to recover for the loss he had sustained. A joint investigation made by the department of water supply, gas and electricity and by the public service commission indicated that the tracks in the neighborhood were poorly bonded and there was a flow of current from them to the sub-station through the intervening marshy ground. The tests indicated that the water mains were carrying heavy currents for some distance toward the sub-station, and that the currents then left the water mains and returned through the damp soil. The conditions were such that one of the lead service pipes transmitted currents which would theoretically eat away about 15 pounds of metal annually. The joint tests were suspended owing to representations made before the commission questioning its jurisdiction to order circuit changes on the part of the company, which were necessary to a conclusive test.

Nicholas S. Hill, Jr.: In 1895 were were installing in Baltimore near an electric railway power station an underground conduit system for telephone and telegraph cables. We laid lead-covered cables with their ends tied together, but in three weeks' time the lead covering was entirely gone. The cables were laid in a weak solution of sewage and everything was favorable for corrosion. The action was so rapid that it was necessary to make an electrical survey at once. We did not know then as much about electrolysis as we do now, and the first thing we thought of doing was to connect the cables with the busbar of the power station. When this was done we found that we were returning about 1,800 out of the 2,800 amperes supplied by the station.

There is but one solution of the problem of electrolysis. That is insulation of the rails so far as possible and increase in the conductivity of the track circuit back to the station within economical limits. It is unwise to attempt to force methods upon the railways, which are so expensive that they are prohibitive. I have felt, and this opinion is substantiated by the decisions in the suits brought at Peoria, Indianapolis, Dayton and elsewhere, that we gain nothing by bringing suits which attempt to force a particular kind of construction on the railways, because when the water department or water company appeals to the courts on such a basis, the construction demanded is such that it is easy to prove to the courts that such a requirement amounts to confiscation, and the courts are loath to do anything which has even the appearance of confiscation.

The attitude of this association in the matter of electrolysis should be one of co-operation and arbitration rather than one of coercion. If damage is done, we have the same methods of recovery that any person has by bringing suit to force the offender to pay for the damage he actually does, but I do not believe we can profitably use the courts in any other way than the recovery for damage sustained. We are working in the streets in conjunction with other public utilities and we all have equal rights in them. What we should do is to co-operate with engineers, who are better equipped by training to attack the problem of electrolysis, and to formulate with them remedial measures and standards of construction which will reduce this trouble to a minimum.

D. W. French: I do not think the experience the Hackensack water company has had from electrolysis is unlike that of any other water company. We have usually found that such trouble as we had was due to poor rail bonding, and when voltmeter readings exposed what was going on and the matter called to the attention of the railway officials, they were generally remedied. A number of lead service mains have been completely ruined by stray currents, and these services have been replaced by the railway company at their expense.

Hermann Rosentreter: We have found an unusual instance of the straying of return currents in New Jersey. There is an electric railway running south westerly from Paterson and paralleled by a 42-inch main supplying Jersey City. A 42 and a 48-inch main supplying Newark intersects the railway and runs directly away from the station supplying current for the cars. A leak in the Newark mains was reported in a swamp about 3½ miles from the railway crossing. Investigation showed about 20 amperes flowing in the mains at that place and several miles farther from the power station we found a current of two amperes. In order to be sure that the current came from the railway, measurements were made one night before and after the road was shut down. When the car service stopped the current flowing out over the mains stopped and a small current flowing toward the Paterson power station was observed. In other words, current from the station strayed 11 miles away from the railway on which it was supposed to remain.

Alexander Potter: At San Antonio, Texas, we found the service pipes pitted with what appeared to be electrolytic corrosion. This appeared in all parts of the city and an experiment in the way of protection is now being made. This is to cover the services with tile pipe, which has not been in use long enough to prove its usefulness.

F. T. Kemble: Our troubles with electrolysis in New Rochelle are pretty much the same as those of everybody else, though the points at which it occurs are rather localized. But there is one condition that probably differs from other plants that may be of interest to you. Along the Long Island Sound shore section much of the trolley return current is carried over the tracks of the New Haven Railroad, who have their tracks bonded directly to the busbar in the power-house of the trolley company. Professor Ganz has made a study of our section and is entirely familiar with this condition. As showing one of the channels through which the current has travelled, we have on two occasions found a 1-inch piston meter, which was set on the railroad company's own connection near its tank-house, have its piston so warped that the meter ceased to register. After the second occurrence, which was after an interval of about six weeks, we placed the meter in a vault close to our main, a distance of less than 200 feet from the original location, and since then we have had no further trouble with it.

Allen Hazen: It is well to bear in mind that punk metal is not necessarily due to electrolysis. Iron pipe has been found in a punky condition miles away from any electric railway and where there was no possibility of its being due to electrolysis. In such cases it is doubtless the result of the chemical action of the soil. The alkali in certain western soils seems to have a powerful action of this kind. Several years ago, in building a steel water pipe, at each crossing of an electric railway the pipe was covered with building paper in successive layers, each of which was heavily coated with tar. This treatment was inexpensive and seems to have been in line with the treatment suggested by Professor Ganz.

Prof. Albert F. Ganz: It is not generally possible to satisfactorily answer questions in regard to electrolysis unless complete information stating all of the conditions can be given. It is generally difficult to obtain such complete information from inquiries made in connection with discussions before meetings like this.

I am glad to hear that the department of water supply, gas and electricity of New York City has refused to permit the electric railway companies to bond their water mains to the railway tracks. Such permission should not be granted, because the bonding of water pipes to the tracks makes the water piping system part of the railway return circuit, and almost always makes the piping system carry very large currents, and these become an increasing source of serious danger. Mr. Nicholas S. Hill has well illustrated by his experience in Baltimore that it is of great advantage to railway companies to connect underground structures to their railway return circuit, as they thereby obtain the use of these underground structures for the return of current. He has also shown that these structures are made to carry very large currents by such connections.

In regard to the attempt in San Antonio to stop electrolysis by encasing the water services in tile pipes, I beg to say that this arrangement can only succeed if the joints in the tile pipe and the connection to the water service are made waterproof, so that the space between the service pipe and the tile pipe does not fill with water. If this space does fill with water, then current may continue to flow from the service pipe to the water and produce corresponding corrosion of the service pipe by electrolysis. I would suggest as an improvement that the space be filled with a compound like pitch.

The heating of the 2-inch water meter by current from the New York, New Haven and Hartford Railroad in New Rochelle is very interesting, and I am sorry that I have not more details in regard to this very important observation. Mr. Hazen's remarks emphasize the fact that it is not possible to tell from the appearance of a corroded pipe alone whether it has suffered from electrolysis or from purely chemical action. To determine this requires electrical measurements to see whether current is leaving the pipe which could produce electrolysis.

In regard to lead service pipes which are reported to be destroyed by electrolysis from current reaching the water service pipe from the gas main by way of the house service connections, I would suggest that if this is the path of the current which damages the water service pipe, the trouble can be remedied by inserting an insulating joint in the water service directly inside of the cellar wall, thereby preventing the flow of the damaging current out on the water service pipe. If, on the other hand, the current flows from the water main to the water service pipe, then an insulating joint would have to be inserted in the water service pipe close to the main. A safe precaution would be to insert an insulating joint in the water service pipe both close to the main and directly inside of the building.

In regard to the question of grounding transformer secondaries to water pipes, I would say that there is absolutely no danger in permitting such connections to be made. Transformers operate with alternating current, and the object of grounding the secondaries of transformers is to serve as a safety measure to prevent the possibility of persons obtaining a high voltage shock. Under normal operating conditions there is no flow of current to the water pipe from such transformer connections, and in my opinion such connections can be safely permitted.

COLORIMETRIC TEST FOR ORGANIC IMPURITIES IN SAND.

UNDER the auspices of Committee C-9, on concrete and concrete aggregates, of the American Society for Testing Materials, colorimetric tests for discovering impurities in sand have recently been conducted. The methods employed as well as the data secured have now been issued in a circular, from which the following is abstracted:—

The colorimetric test may be described briefly as follows:—

A sample of sand is digested at ordinary temperature in a solution of sodium hydroxide (NaOH). If the sand contains certain organic materials, thought to be largely of a humus nature, the filtered solution resulting from this treatment will be found to be of a color ranging from light yellow up through the reds to that which appears almost black. The depth of color has been found to furnish a measure of the effect of the impurities on the strength of mortars made from such sands. The depth of color may be measured by comparison with proper color standards.

The colorimetric test has been applied to sands from about 40 widely distributed deposits in 20 different states. The research to date has brought out the following:—

Examinations of deposits of defective sands show that surface loam is the principal source of contamination.

All natural sands which have been found to be defective on account of the presence of organic impurities have responded to the colorimetric test with sodium hydroxide, and all sands which have given high color values have shown low values in mortar tests.

Sands which were similarly graded by screening out and recombining the different sizes to a definite sieve analysis showed a fairly definite relation between the compressive strengths of 1-3 mortars at 7 and 28 days and the color values of the sands.

The mortar-making quality of sands known to contain organic impurities has been much improved by removing the organic matter, either by repeatedly digesting them with sodium hydroxide and then washing free from alkali, or by driving off the organic impurities by ignition.

When the sodium hydroxide extracts from sands which mortar tests had shown to be defective were purified and applied as coatings on high-grade sand, that sand was made "defective" or gave much reduced mortar strength.

It is impracticable to give exact values for the relation between the color value of a sand and the strength of mortars made from the same sand. However, the tests made thus far show this relation to be about as follows:—

Color values of sand.	Reduction in compressive strength of 1-3 mortar. Per cent.
250	10-20
500	15-30
1,000	20-40
2,000	25-50
3,000	30-60

The reduction in strength is based on compression tests at ages of 7 days, 28 days, and 3 months, of 1-3 mortars made from the same sand, before and after coating with different per cents of organic impurities which had been extracted from defective sands and purified. Tests on mortars made from defective sands as received and after removal of the organic impurities, either by repeated extractions with sodium hydroxide or by ignition,

showed that in some cases the reduction in strength for a given color value was even greater than the higher values given above. Frequently the test pieces completely disintegrated in the storage water. The higher reductions in strength for a given color value for a natural sand as compared with the same color value for an artificially coated sand is probably due to the artificial coating being more easily removed by the sodium hydroxide.

Sufficient data are not available to indicate whether or not the effect of a given quantity of organic impurities varies with the grading of the sand. The reduction in strength seems to decrease slightly with the age of the test pieces.

The concluding remarks in the circular follow:—

Impurities in sands other than organic, such as clay or similar admixtures, if present in considerable quantities, may be expected to affect the strength of the concrete. However, the examination of a large number of defective sands has shown that it is the organic impurities of a humus nature which are responsible for the abnormally low strengths of such sands.

It has been found that the colorimetric test can be made with a greater degree of uniformity by different operators than can the strength tests of mortars from the same sands.

The fact that the colors produced by digesting certain natural sands with sodium hydroxide are similar to those produced by treating tannic acid in the same manner must not be interpreted to mean that the organic matter in sands is necessarily tannic acid, or even a tannate. The chemical compounds which make up the organic material are probably numerous and complicated.

The time actually required for a single determination by the laboratory method is about one-half hour. If tests on as many as 5 samples can be made at once, the total time consumed need not exceed 1 hour. The time required from the beginning to the end of the test is about 24 hours.

Inexperienced operators without technical training or previous experience in work of this character have secured satisfactory results at their first trials.

The strength test of mortar is used as the criterion of the effect of impurities in sand. In making strength tests of sand mortars and interpreting the results of such tests, the following points require particular attention: (*a*) Sampling of sand; (*b*) grading of sand; (*c*) quantity of water used in mixing; (*d*) methods of mixing, molding and testing; (*e*) form and size of test piece.

(*a*) Great care is necessary to insure that the sample tested is representative of the larger lot of sand. Good judgment and considerable experience are necessary to secure representative samples from an undeveloped deposit. Some form of sampler should be used in the laboratory in selecting a test sample from a larger lot.

(*b*) The size and grading has an important influence on the concrete and mortar-making qualities of sands. A sand graded from coarse to fine, with the coarse particles up to about $\frac{1}{4}$ in. in diameter, is desirable for use in concrete. Fine sands, when mixed to the same plasticity, give mortar strengths much below those of coarse, well-graded sands. The influence of the grading of sand on the strength of the mortar must not be confused with the effect of impurities.

(*c*) The quantity of water used in mortar tests has just as important an influence on the strength as the amount of cement. The quantity of water required for normal consistency of mortar made from a given cement is a function of the grading of the sand.

(*d*) The methods used in mixing, molding the test pieces, storing and testing the specimens, etc., used in standard tests of cement should be followed in making strength tests of sand mortars.

(*e*) Compression tests of mortar are believed to be more significant than tension tests. A 2-in. by 4-in. cylinder has been found to give satisfactory results as a compression test piece. This is the form of test piece recommended by the American Society for Testing Materials in their proposed tentative specification for compression tests of cement.

The study of impurities in natural sands is being continued as a part of the work of the Structural Materials Research Laboratory, Lewis Institute, Chicago. Special attention will be given to further improvements in the colorimetric test, and to discovering remedial measures which can be used in a commercial way for counteracting the effects of such impurities.

ETHICAL QUESTIONS ANSWERED.

IN order to arrive at some approximate idea as to what attitude ethically engineers should assume under certain conditions, the American Institute of Consulting Engineers has answered certain ethical questions, these answers being based upon facts coming under the notice or practice of engineers, or upon hypothetical situations.

The first questions, along with the approved answers, have now been sent out. Some of these follow. These questions and answers are handled by a special committee appointed for the purpose.

1. *Question*—Is it proper or wise on the part of A to accept responsibility without personally investigating or verifying the accuracy or adequacy of surveys and data supplied by B?

Answer—It would be unwise for A to proceed without personally satisfying himself of the adequacy and accuracy of the data supplied by B, unless it were distinctly understood or stated in the terms of A's engagement that he should assume no responsibility for the correctness of the data supplied to him. Such review and verification is desirable in order to protect both the client and the engineer from the consequences of erroneous data or misunderstood conditions.

2. *Question*—Would it be unethical for an engineer to accept and act on the proposition of a patent attorney to solicit or turn over legal work to him on a fee-sharing basis?

Answer—The sharing of fees or profits as compensation for soliciting engagements is regarded among engineers as unethical. This does not apply to the division of fees in cases where two or more engineers are jointly employed or engaged upon the same work.

3. *Question*—Is it unethical for engineers to permit the use of their names as references in business enterprises, or for the promotion of business schemes?

Answer—It is regarded as at least imprudent for an engineer to permit the use of his name as a reference regarding the character and responsibility of persons or business concerns for advertising purposes. The practice might lead not only to personal embarrassment but to the discredit of the profession.

4. *Question*—Is an engineer entitled to claim and receive the whole amount of the fee which would be due him if work suspended for good reason had gone on to completion?

Answer—Such contingencies should be provided for in the original agreement between engineer and client. In the absence of such a provision, and unless the circumstances should warrant a different action, and particularly where the abandonment occurs through no fault or bad faith on the part of the client, settlement upon an equitable basis for the work already done, and the expenses and obligations already incurred, would be fair and just to both parties.

5. *Question*—Should engineers recognize or take part in such public competitions for services where it is to be presumed that the lowest bidder will be engaged for the services?

Answer—It is not regarded as ethical for reputable engineers to enter such competitions. This does not, however, apply to competitions for designs for a specific structure where such competition is properly conducted and provision is made for reasonable compensation for rejected designs.

6. *Question*—If in the course of an investigation an engineer makes discoveries which, while foreign to the subject of his specific engagement, are so related to the business of the client as to be of great importance to him and, if disclosed, might seriously affect that business, does the present ethical relation of the engineer to his former client permit him to develop these discoveries for his personal use or profit, or to publish an account of them in the interest of science?

Answer—The engineer should not make use of information or discoveries, or the results therefrom, obtained while in the service of a client, in any manner adverse to the interests of the client.

WORK ON THE PANAMA CANAL.*

By Henry Goldmark, M.Can.Soc.C.E.

BEFORE the Canadian Society of Civil Engineers, Montreal, March 22nd, Mr. Henry Goldmark, M.Can.Soc.C.E., delivered a most interesting address dealing with the work on the famous waterway. The description which Mr. Goldmark gave was illustrated by a number of official slides of the United States Government.

At the conclusion of Mr. Goldmark's address the chairman, Mr. J. M. Robertson, invited those present to ask any questions, assuring them that Mr. Goldmark would be very glad to answer them.

The following questions were put to the speaker of the evening, which, together with his answers, will be of interest.

Q.—Would Mr. Goldmark kindly tell us if the reports of the tests on the chain fenders have been published?

A.—Mr. Goldmark: Yes, in the last report of the Panama Canal, which was published last September or November, they have given some of those tests, but I have been thinking somewhat of giving a rather fuller account of them some of these days. You could find, however, in the annual report of 1916 some of the actual figures, showing just what they found.

Q.—Could you tell us something of the question of fresh water having been mixed with the salt?

A.—Mr. Goldmark: Theoretically, you get a certain amount of salt water up in all these lakes. We knew there was, but it came to my attention, and I studied it in connection with the moving of lock gates under certain conditions. As a matter of fact, there is a *rise* there that has been sticking tide machinery. Some said there wasn't that it was all nonsense. It is not all nonsense; it is theoretically right, and we found that you have to press against six inches, and you get that on the heavy currents into the ocean, so it interferes slightly with navigation. There is a little lake between Pedro Miguel and Miraflores that was intended for the water supply of Panama, and the question arose that there would be a certain amount of chlorine in there. It was a question whether to run the pipe on and take the water from the upper Charges, which would cost half a million dollars, or take the water from the Miraflores Lakes. They decided on the latter course and spent $20,000 on certain foundations, and when they had a small amount of vessel traffic Miraflores Lake got so salty they couldn't drink it. This condition compelled them to carry the pipe on at a cost of $500,000. As a matter of fact, the water gets salty when the vessels go down and when they come up.

Mr. Swan: One or two points occurred to me that I would like to ask Mr. Goldmark about. One was: In testing the lock gates did you fill them with water?

Mr. Goldmark: Yes, we filled them with water. You see, the lower part was an air-chamber, and originally I didn't like the idea of using an air-chamber to fill the water from the inside, but ultimately it was proven to be the only way. At the top we moved the water from one compartment to the other, and we also tested the strength of these pockets and corrected all the leaks. The contractors thought I was very severe in testing on riveting and caulking, but after all I think it was very worth while, as in the thirty or forty thousand we had perhaps only one hundred caulked.

Mr. Swan: I might say that in other gates with which I have been associated we invariably filled them with water, and I have had the principle criticized in this way: A shipbuilder when he builds a ship doesn't fill it up with water; why should an engineer when he builds a gate go and fill it up with water? It was an argument we could not very well work against. Whether the shipbuilder is more perfect in his work and doesn't require to do so, or whether it is the engineer in that sort of work is more particular, I don't know.

Mr. Coutlee: Gentlemen, it has given me the greatest pleasure this evening to hear my old friend, Mr. Goldmark, go over in review that very great work with which he was so long connected. Having had the opportunity of seeing it after, one can appreciate the enormous effort and the tremendous development of mechanical ideas that took place on the Isthmus. A lock type was adopted that has proven absolutely satisfactory. It has set a type and size for locks the world over, and it has dictated to the marine world that they must learn to lock ships. There has been very little difficulty experienced, I understand, so far, in passing through. Of course, the captain is no longer the captain in passing through the locks.

I think that the matter Mr. Goldmark spoke of a few moments ago in connection with balancing the salt water pressure at the lower locks has not been a very great difficulty. But I would like to ask Mr. Goldmark if there was not an arrangement in the outgoing culverts of that lower lock thought of at one time?

*Abstracted from notes of meeting of the Canadian Society of Civil Engineers, Montreal, March 22nd, 1917.

Mr. Goldmark: It was put in. When that question came up it was referred to a committee in the Lock Department, of which I was a member, and we made a report which showed very clearly that we thought there would be that trouble, but we proposed a very foolish solution. We proposed a ballast gate or a flat valve. I have always thought it was a very incorrect solution, because that flat valve would have to have been about eight or nine feet in size. . . . We later had another committee on it, and there were two questions. One was the closing on a slow and the other a rapid rising of tide, which would reverse the pressure against the gates, and the gates were rigidly held. What they ultimately did to take care of rapid rise of tide was nothing, and they still have that risk. If the valves should be closed at the lower end of the locks and the gates also be closed and the tide rise rapidly they may have trouble.

At the close of his address the meeting passed a hearty vote of thanks to the speaker.

A pleasing function followed, namely, the presenting of the Gzowski medals. Owing to the unavoidable absence of the president, Mr. J. S. Dennis, Mr. R. A. Ross, vice-president, kindly consented to officiate at this point.

In presenting the medals, made possible by the fund which was left by Sir Casimir Gzowski for that purpose, Mr. Ross referred to the paper which it had been decided should receive the award this year, namely, the paper on the Cedars Rapids power plant, the joint authors of the paper (it being in three parts) being Messrs. Henry Holgate, R. M. Wilson and Julian C. Smith. Of the three authors only Mr. Smith was present. In accepting the medal Mr. Smith expressed his warm appreciation of the action of the committee for the honor conferred.

FOURTH CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS, OTTAWA, APRIL 10-14.

THE success of the Fourth Canadian and International Good Roads Congress at Ottawa, April 10-14 inclusive, is already assured from the educational point of view, for the president (J. Duchastel, of Outremont) and the secretary (G. A. McNamee) have already received acceptances of invitations to read papers from some of the best-known highway engineers on the North American continent.

The morning and afternoon sessions of the congress will be fully occupied with papers and discussions dealing with every phase of the road question.

Many old friends of the congress will once more be found on the programme, men who may be regarded as pioneers in the making of improved roads. Such men as Col. W. D. Sohier, chairman of the Massachusetts Highway Commission of Boston, and James H. MacDonald, ex-state highway commissioner of Connecticut, whose experiences in overcoming difficulties similar to those that Canadian road builders have to face would make the congress a success alone if they were the only speakers. Then there are others coming from the United States to emphasize the international character of the congress and the universal importance of good roads. Among them are W. H. Connell, chief engineer of the Department of Public Works, Philadelphia; B. D. Sargent, chief engineer of the State Highway Commission of Maine, and Professor A. H. Blanchard, professor of highway engineering, Columbia University.

The Canadian speakers at the congress will be more than usually representative. From the Dominion Government there will be L. Reinacke, of the Geological Survey Department, who will give some useful information regarding road materials, and Thomas Adams, town-planning adviser to the Commission of Conservation.

The Ontario Government will be represented by one of Canada's leading highway engineers, W. A. McLean, the deputy minister of highways for the province.

Ontario is moving rapidly this year in its desire for good roads, and important legislation dealing with highway construction is going to be introduced at the coming session of the legislature. Mr. McLean will give a talk on the highway system of France, illustrating it with a series of fine lantern views made from actual photographs taken in what is now the war zone, and showing the world-famous highways of France which have been such an important factor in the great struggle. The Ontario Highways Department will also be represented by G. Hogarth, W. F. Huber and G. C. Parker, all of whom will contribute to the proceedings.

From the Provincial Government of Quebec there will be the deputy minister of highways, B. Michaud, who was president of the congress last year; his chief engineer, G. Henry, and A. Fraser and M. E. Fafard, also of the provincial engineering department.

In addition to these, papers will be contributed by T. Harry Jones, city engineer of Brantford; A. F. Macallum, commissioner of works, Ottawa; W. G. Yorston, assistant road commissioner, Halifax; Paul E. Mercier, chief engineer of the city of Montreal; Col. F. A. Snyder, Montreal; L. Burtubise, city engineer, Montreal East; T. Baillarge, city engineer of Quebec; Malcolm Barclay, and L. E. Schlemm, of Montreal; P. Jarman, city engineer of Westmount; A. Lalonde, Outremont; E. Drinkwater, St. Lambert, and others.

The Congress will be more than usually important this year because of the labor conditions caused by the war and by the possible return of the Canadian soldiers in the near future. Speaking on this point the president of the Dominion Good Roads Association, J. Duchastel, says: "When the war is at an end the condition in Canada will be a very serious one. We will have our returned soldiers to look after as well as a large influx of immigrants. Very little employment will be available in industrial centres because our factories which are now producing munitions of war will have to seek other fields for their product and there will necessarily be some delay while they are re-transforming their machinery to the production of the articles that will be required. There will also be little employment available on the railways because this work has been so extensively carried on in the past few years that there are not likely to be any big extensions for the next few years. Therefore, the only employment on a large scale that men will find will be road construction, which should be undertaken not only by the provincial governments, but by the Federal Government, for the country needs good roads if it is to develop properly. Well-constructed highways, properly maintained, are a benefit to all classes of the community and the rural districts will probably benefit more from them than any other section, for good roads should always be built with the idea of acting as feeders to the railway lines or to the large commercial centres, thus allowing the farmers to haul their produce to these places at a minimum cost.

It is reported that a group of iron and steel manufacturers in the East district of France are interested in a scheme for the establishment of a steel-making plant and a large battery of coke ovens in the Paris district.

The Engineer's Library

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BOOK REVIEWS.

Economic Geology. By Heinrich Ries, A.M., Ph.D., Professor of Geology at Cornell University. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. Fourth edition, 1916. 876 pages, 291 figures, 75 plates, 6x9 ins., cloth. Price, $4.00 net. (Reviewed by J. B. Tyrrell, mining engineer, Toronto.)

The great increase in the production of mineral wealth in Canada during the past few years has raised the Dominion to the position of one of the important mining countries of the world. In many other countries in which there has been an increase in the production of the mines this increase has been in large part due to improved mechanical appliances for extracting the ore from the earth or to new or better chemical processes for extracting metals from their ores after these ores had been mined. But in Canada the increased production has been largely due to continued discoveries of the existence, or farther extent, of valuable bodies of ore of one kind or another, and on account of the vast areas of territory yet unprospected we may expect that such discoveries will continue to be made in increasing ratio for many years to come.

The work of discovering and developing bodies of ore in the rocks of the earth's crust, however we may think of it or refer to it, is simply geological work and the problems involved are problems in geology.

In order to distinguish the study of the character, extent, and value of bodies of ore or useful minerals from the study of the principles which govern the formation of rocks generally, and the relations which they bear to each other, this study is usually referred to as "Economic Geology." It will be seen, therefore, that a knowledge of our economic geology, whether we know such knowledge by that name or not, is of vital interest to us as a mining people.

We therefore welcome the fourth edition of Dr. Ries' excellent volume on economic geology of the United States and Canada, not so much for the descriptions which it gives of individual mineral fields as for the well-arranged characterizations of the ores and useful minerals that are found throughout the northern portion of the American continent and of the various ways in which these ores and minerals occur as well, as some account of the rocks with which they are usually associated.

The book is a volume of xviii. + 856 pages and is divided into two parts of 425 and 399 pages respectively, Part I. dealing with Nonmetallics and Part II. with Ore Deposits.

Under "Nonmetallics" are 13 chapters with the following headings: 1, Coal; 2, Petroleum, Natural Gas and other Hydrocarbons; 3, Building Stones; 4, Clay; 5, Limes and Calcareous Cements; 6, Saline and Associated Substances; 7, Gypsum; 8, Fertilizers; 9, Abrasions, 10-12, Minor Minerals; 13, Underground Waters.

To illustrate his mode of treatment of a subject we may take the headings in Chapter 2, on petroleums, etc. Introductory; Properties of Petroleum; Properties of Natural Gas; Origin of Oil and Gas; Inorganic Theory; Organic Theory; Mode of Occurrence; Classification of Oil and Gas Sands; Mode of Accumulation; Yield of Sands; Life of a Well; Distribution of Petroleum in United States, with brief description of the fields from the Appalachians to Alaska and also Canada and Mexico; Distribution of Natural Gas in the United States and in Canada; Uses of Petroleum and Uses of Natural Gas; Solid and Semi-solid Bitumens, including Albertite, Anthraxolite, Ozokerite, etc.; Bituminous Rocks, Oil Shales; Production; References.

From the above list it will be seen that an enquirer would be able to find here answers to all ordinary questions that would occur in dealing with petroleum, etc., and if he should wish to pursue the subject farther the references would guide him to the places where he could obtain fuller information.

Part II., "Ore Deposits," begins with a chapter on ore deposits in general, in which, after offering a useful definition for them, he discusses their origin and mode of formation, and whether they have been formed at great, intermediate or shallow depths in the earth's crust. He also describes the various forms of ore bodies, the secondary changes which may have occurred in them since their original formation, and then suggests a classification under which they may be grouped together.

The chapters that follow deal with ores of iron, copper, lead and zinc, gold and silver, and minor metals, under which are placed nickel and cobalt. Unfortunately, the silver mines at Cobalt, Ontario, have been described under these latter metals, and more unfortunately still they have been omitted from the index, though this will doubtless be corrected in a subsequent edition.

The book will be of great interest to all who are anxious to acquire a good knowledge of the useful minerals and ores of the northern portion of this continent.

It is beautifully printed on fine glazed paper, is illustrated by 75 plates and 291 illustrations, including maps and diagrams, and is furnished with an index of 28 pages, in which almost everything referred to in the book can be found.

Hydro-Electric Power, Vol. 1, Hydraulic Development and Equipment. By Lamar Lyndon. Published by McGraw-Hill Book Co., Inc., New York. First edition, 1916. 499 pages, 235 figures, 6x9 ins., cloth. Price, $5.00 net. (Reviewed by Arthur Surveyer, M.Can.Soc.C.E., consulting engineer, Montreal.)

In the last few years many books have been published in the United States on hydro-electric practice, and almost each new volume has been an improvement on the previous works. This new book by Mr. Lamar Lyndon, which has for companion a second volume on "Electrical Equipment and Transmission," is no exception to this rule. It is also a great improvement on the other book published on the same subject, by the author, in 1908, and entitled "Development and Electrical Distribution of Water-Power." In this new book has been included the most recent important contributions which have appeared in the technical publications with the possible exception of Robert E. Horton's new category of coefficients of roughness for use in Kutter's formula, and Mr. Schaefer's "German Studies of Uplift Pressure on Masonry Dams." In his preface, the author states that it has been his intent "to produce a work for the guidance of the engineers in the practical design of hydro-electric plant, which would have a character of accuracy, clearness and completeness." The author has thought it advisable to repeat occasionally in different parts of his book, both statements and conclusions, as well as the meaning of the symbols used in the formula. The reason given for this modification is that treatises of this character are seldom read through consecutively, but are used for reference, and that it is both an annoyance and a waste of time to search through every part of a book for data on some single subject. The writer feels sure that this feature will be much appreciated by engineers who have been compelled in the past to read half a book in order to find out what a symbol meant in a formula, or what were the previous conclusions. The value of the book is also greatly enhanced by the numerous numerical examples given in the text.

The first chapter deals with general conditions and does not contain any new matter. The second chapter treats of the flow in streams and the run-off from the basin. The author gives the following method for determining the probable high-water discharge: "If a line of levels be run which shows the slope of the level of the water surface as indicated by the marks left by the flood, and several cross-sections be taken, sufficient data will be obtained to compute, within practical limits, the flow at the time of the flood." This appears to the writer as a very doubtful method, as a very slight variation in the slope would cause the calculated flood discharge to vary within excessive limits. As noticed above, this chapter does not include Horton's values for n in Kutter's formula, but only the old-time table which gives nine subdivisions only. It contains, however, a very valuable method for the determination of the back-water curve caused by a dam. The formula given is much simpler than Bresse's old formula and apparently more accurate than Dupuit's, both of which have been doing service for over half a century. In the measurement of stream by floats, Mr. Lyndon refers only to the surface float method, which is not very accurate, and does not refer to the submerged float method nor to the rod float method, which are both more dependable. The Mississippi River was gauged by Abbott and Humphrey by the submerged float method, and valuable formulæ for the discharge of rivers deduced from these observations. The writer has used both the submerged and the rod float method, with good results, to measure volumes of over 100,000 cubic feet per second.

Chapter 3, entitled "Weirs and Orifices," refers to the flow over weirs of various shapes and to the discharge through sluice gates and penstock intakes. The coefficients of discharge through sluice gates given as the result of experiments made in India and at Lowell, Mass., vary from .74 to .95 and appear very high to the writer. A coefficient of 0.62 has long been considered as a fair average when contraction took place on four sides and 0.80 when contraction was entirely suppressed.

Chapter 4 deals with "Power Variation and Storage"; Chapter 5, on "Artificial Waterways," contains valuable information on the flow through canals, the limiting velocity of water for various materials, seepage losses in canals, etc. The subject of open flumes is very well handled and the analysis given of the stresses in wooden flumes includes the stresses in the trestle work. Concrete flumes are also analyzed and complete method of calculation given. This information is not easily found elsewhere and is very valuable.

Chapter 6, "Pipe Lines and Penstocks," is a very important one; it contains the calculation of the different losses in pipes, also the determination of the size of the pipe and the computation of the discharge for a system of varying cross-section. The author gives a formula for the calculation of the distance between penstock supports which he does not consider satisfactory. Mr. R. A. Wright gave one in "Engineering News" of February 10th, 1910, in an article entitled "Steel Supports," which appears to fit the problem better.

Chapter 7, on "Dams," is perhaps the most important of the whole book. The problem is very well presented and the explanations clearly given. The author considers that the effect of the uplift force (due to hydrostatic pressure under the base) is substantially negligible and that any failure of a dam, by overturning, must be assigned to other causes. He argues that the most dangerous condition that must be provided against is, full pressure at the upstream edge and no pressure at the toe. This uplift pressure applying only over 25 per cent. of the area of the base. The arguments brought forward sound convincing, but they are in contradiction with the results of some experiments made at the Oester and Neye dams in Germany to determine the uplift pressure and summed up by Mr. Schaefer in an article entitled "German Studies of Uplift Pressure on Masonry Dams," which was abstracted by Mr. Alfred W. Hoffmann in "Engineering and Contracting" of September 22nd, 1915. The two dams examined were built on rock foundation of grey wacke and slate of widely varying description. The conclusions arrived at by Mr. Schaefer are that "every dam is subjected to some uplift pressure, even if the greatest care has been exercised in the selection and preparation of the foundation." Mr. Schaefer recommends that in the designing, the full hydrostatic pressure due to the maximum head be assumed at the heel and one-half the pressure at the toe, the pressure being effective over the entire area and decreasing uniformly from the heel to the toe. A dam is to be considered safe and stable if the resultant does not pass closer to the toe than ⅓ the width of the base. Applying the methods suggested by Mr. Schaefer to the dam described and shown by Mr. Lyndon on page 198, we find that instead of having a factor of safety of about three, as is the case when the Lyndon method is followed we have a factor of safety smaller than unity and a resultant falling outside the base. This chapter also includes valuable discussion on foundations

of dams on rock, on sand and on clay. A complete example of the method of calculation of a hollow reinforced concrete dam is also given. Expansion joints in dams and reinforced concrete retaining walls are also included in this chapter. Reference is also made to earth dams and hydraulic fill dams.

Chapter 8, on "Movable Crests for Dams," contains a good deal of information which is not available in the other books, and describes flash boards, automatic crest gates and their protection. Stoney roller gates, Stickney gate, automatic gates with rolling counterweight, Taintor gates and rolling dams.

Chapter 9, on "Headworks," refers to stop logs, log booms and the analysis of the forces acting upon them, trash racks, loss of head through racks, head-gates, head-gates hoists, and the Johnston valve.

In Chapter 10, on "Water Wheels," the author very wisely limits his discussion to the mixed flow reaction turbine and the curved-bucket impulse wheels which are the two kinds in use at the present time. The principal headings of this chapter are: The theory of the reaction turbine; unit quantities; relationship between speed, power, discharge and diameter; turbine characteristics; efficiency and size of wheels; wheel setting; details of turbine design; design of concrete scroll cases and draft tubes (two of the most valuable features in this chapter and due to Mr. A. G. Hillberg); the theory of the impulse wheel and details of its construction and regulation.

Chapter 11, "Speed regulation of Water Wheels and Abnormal Penstock Pressures," contains much information hitherto scattered in various publications. Its principal sections are: Speed regulation of water wheels; energy delivered by flywheels; the moment of inertia of generators; acceleration of moving column of water; effect of change in head on water wheels; time period of governor; water hammer; relief valves; surge tanks; computations for surge tanks; differential surge tanks; pipe vents; vent or air valves and water wheel governor.

The author's invitation to "criticisms from engineers who are new in the art," is probably responsible for this somewhat lengthy review of his book. In closing, the writer would like to say that, notwithstanding the few remarks made, this work compares most favorably with the half dozen or so of other American books on the same subject. The engineer engaged in the design of hydraulic plants proper, not including the design of the hydraulic machinery, will probably find Mr. Lyndon's book the most useful one yet published in English.

Practical Sanitation. By Dr. George Reid. Published by Charles Griffen & Co., London, Eng. 18th edition, revised. 356 pages, 5 x 7½ ins. Price 6d. (Reviewed by R. O. Wynne-Roberts, Toronto.)

The fact that this book has now reached its eighteenth edition is an indication of its value, for few books survive long enough to demand several editions. It has been written more particularly for the use of inspectors and those connected with sanitary inspection in Great Britain. The context deals with sanitation generally as it is considered in temperate climes. But there are many conditions in Canada which are peculiarly Canadian and the reader must bear this in mind when perusing the book. For example, houses are built differently in many respects, heating, ventilation or the absence thereof, drainage, insulation, and so on have to be provided in a different manner. Soil pipes are always placed outside the dwelling in temperate countries, but difficulties would ensue if that practice was observed here. Ventilation, especially in the winter time, is a problem not always easy to solve, and consequently some of the methods advocated in this book will not be practicable. Water will no doubt improve in quality by prolonged storage. Dr. Houston, one of the eminent authorities on water purification, has the greatest confidence in this factor in the treatment of water. During the winter, however, the open reservoirs will be frozen over for many weeks and the effects of the sun and the atmosphere are greatly modified, and the bacteriological improvement will no doubt be slight. Sterilization is a common method of treating doubtful waters in North America, but in other countries it is not by any means so generally carried out. Slow sand filters are the standard types in temperate countries, but rapid sand filters are probably more largely adopted in these parts.

The quantity of water used and misused on the American continent is greatly in excess of that in Europe and the standards of practice in the distribution and waste detection are somewhat different. Few cities in other parts of the world resort to the general use of meters to conserve the water, whilst many cities in North America have adopted meters as a measure for preventing waste.

Natural ventilation of large buildings in Canada is hardly feasible; mechanical means of propelling and withdrawing the air have to be installed, and the air warmed, humidified, washed and cooled according to the season and circumstances. Fire places are virtually ornaments in these parts, excepting in few instances, and yet if the matter was properly investigated it would, no doubt, be found that suitable grates and fire places would be beneficial, comfortable and economical.

Plumbing work, as a rule, is under rigid control and inspection in the larger cities, and should be in all villages and towns, for the health and amenity of the people are matters of great importance to a community.

Dr. Reid refers to the aeration of sewage by mechanical means as being too costly, and further on deals with the activation process as being in an experimental stage. Having regard to the amount of investigation which has been made and to the works which are now in operation in England and America, it would appear that this subject has not received the fullest consideration.

When treating with infection and disinfection and food, Dr. Reid presents facts which are useful in all parts of the world, and as sanitation in its general principles is international in character, this book will be found useful to those interested in the subject.

Compressed air water supplies, testing of drains by compressed air under pressure exceeding one or two pounds, and the general principles of domestic lighting are not referred to. Water testing of drains is not uniform in character, especially when regard is paid to the plumbing in higher buildings and in winter weather, whereas compressed air under, say, 5 or 10 lbs. pressure would be not only uniform but available under almost all conditions. This volume contains numerous clear illustrations and is well got up.

Practical Oil Geology.—By Dorsey Hager. Published by the McGraw-Hill Book Co., Inc., New York. Second edition, 1916. 187 pages, illustrated, 5 x 7½ ins., leather. Price, $2.00 net. (Reviewed by J. B. Tyrrell, mining engineer, Toronto.)

The dedication is "To the Practical Oil Man of America, with the hope that the book will bring him to a better understanding of the relation of the Geologist to the Petroleum Industry." Part of its usefulness is here

expressed, but in addition it will serve as a textbook for young oil geologists, and it will assist in the formation of intelligent public opinion which is so greatly needed, not only in those parts of the country where oil or gas may reasonably be expected to be found, but in all Canadian cities where the people may be urged to buy stock in companies that are endeavoring to exploit oil lands. Such intelligent public opinion would have been particularly serviceable in Calgary rather more than two years ago, when people were being so easily separated from their money.

The modes of occurrence of petroleum and gas are described in a clear and interesting way and the descriptions are assisted by a large number of plates and diagrams. The methods adopted by geologists in locating pools of oil are described so lucidly and simply that there might be a possible danger of the untechnical reader thinking that technical training was not necessary for such simple location work, but that he could do it quite well himself. Very large amounts of money have been spent by men who have thought that they could do their own geological work cheaper than trained geologists could do it for them. In legal matters, lawyers have persuaded the people that only "fools" try to do their own legal work. Those who try to do their own geological work put themselves in the same class. They usually endeavor to cover up or explain away their own mistakes by abusing the ignorant "geologists."

The book is well printed on good paper, and is of convenient size to be carried in the pocket. Unfortunately a number of errors in proof-reading mar some of the pages.

PUBLICATIONS RECEIVED.

Toronto Railway Company.—Twenty-fifth annual report, 1916.

Canadian Society of Civil Engineers.—Transactions of the Society from October to December, 1915.

Feldspar in Canada.—By Hugh S. de Schmid, M.E. Published by the Department of Mines, Ottawa.

Mines Statements for the Year 1915.—By the Hon. W. D. S. MacDonald, Minister of Mines, New Zealand.

London Street Railway Company.—Forty-second annual report for the year ended December 31st, 1916.

Why Build Fireproof?—A 22-page illustrated pamphlet, published by the Portland Cement Association, Chicago.

Report of the chief engineer of the Board of Estimate and Apportionment of the city of New York, for the year 1915.

Geology of Kingston and Vicinity.—By M. B. Baker. Twenty-fifth annual report, issued by the Ontario Bureau of Mines, 1916.

Onaping Map-Area.—By W. H. Collins. Memoir 95 No. 77, Geological Series. Published by the Department of Mines, Ottawa.

Hydrometric Surveys.—Report of hydrometric surveys for the calendar year 1915. Issued by the Department of the Interior of Canada.

Public Road Mileage and Revenues in the Southern States, 1914.—Bulletin No. 387 issued by the Department of Agricul ure Washington, D.C.

Coal and Coke in Canada.—Report of the production of coal and coke in Canada during the calendar year 1915. Issued by the Department of Mines, Ottawa.

The Nature and Origin of Petroleum and Asphalt.—By Clifford Richardson. Reprinted from "Metallurgical and Chemical Engineering," January 1st, 1917.

Integral Curb for Concrete Pavement.—An 11-page illustrated leaflet, published by the Portland Cement Association, 111 West Washington Street, Chicago.

Highway Engineering.—Proceedings of the second annual short course in highway engineering held at the University of Michigan, February 21st to 25th, 1916.

Canadian Society of Civil Engineers.—Presidential address of F. C. Gamble, delivered at the annual meeting of the Society, held in Montreal, January 26th, 1916.

Mineral Production of Canada.—Preliminary report of the mineral production of Canada during the calendar year 1916. Issued by the Department of Mines, Ottawa.

Asphalt Pavements, Specifications and Properties.—Bulletin No. 12, issued by the Kansas City Testing Laboratory, 1013 Grand Avenue, Kansas City, Mo. Price, 50 cents.

Sun Oils: Barrels.—Fifth of a series of pamphlets issued by the Sun Co., 1428 South Penn Square, Philadelphia, Pa., on the progress and rapid growth of the oil industry.

Timber Import Trade of Australia.—Report prepared by H. R. Macmillan, Canadian Special Timber Trade Commissioner. Supplement to weekly bulletin issued by the Department of Trade and Commerce, Ottawa.

Structural Materials.—Report of the production of cement, lime, clay products, stone and other structural materials in Canada during the calendar year 1915. Issued by the Department of Mines, Ottawa.

Mineral Production of Canada, 1915.—Advance chapter of the annual report on the production of copper, gold, lead, nickel, silver, zinc, and other metals in Canada for 1915. Issued by the Department of Mines, Ottawa.

Importance of the Relation of Solid Surfaces and Liquid Films in Some Types of Engineering Construction.—A paper read before the Western Society of Engineers at Chicago, November 20th, 1916, by Clifford Richardson.

Cobalt Alloys with Non-Corrosive Properties.—By Herbert T. Kalmus, B.Sc., Ph.D., and K. B. Blake, B.Sc. Report of researches on cobalt and cobalt alloys, conducted at Queen's University, Kingston, Ont., for the Mines Branch of the Department of Mines, Ottawa.

The Thames-Victoria Embankment Pavement.—A record of experience from which there was evolved a wearing surface to carry successfully the exceptionally heavy traffic of London's famous thoroughfare. Pamphlet issued by the Barber Asphalt Paving Company, Philadelphia, Pa.

Sewage Treatment by Aeration and Activation.—By George T. Hammond, Engineer of Design and in charge of the Sewage Experimental Station, Bureau of Sewers, Brooklyn, N.Y. Reprinted from the Proceedings of the American Society of Municipal Improvements, 1916. 101 pages, illustrated.

CATALOGUE RECEIVED.

Asphalt, Road Oils and Road Binders.—A 29-page illustrated booklet describing the asphalt, road oils and road binders for sale by John Baker, Jr., Suite 820-822 Marine National Bank Building, Buffalo, N.Y.

Editorial

"WANTED—A CHEAPER ENGINEER."

Members of the Canadian Society of Civil Engineers who have been discussing the necessity of having tthe Society support its members in any disputes with municipal councils where the engineers are unfairly treated, will be interested in the following item which appeared in the Toronto "Mail and Empire" under the heading, "Kitchener Wants A Cheaper Engineer":—

"Kitchener, March 20.—Pursuing its policy of retrenchment the city council by a vote of eight to six has decided to call for applications for a city engineer, although no charges of incompetency have been preferred against the present official, Herbert Johnston, who has held the office for the last eight years. Engineer Johnston is receiving a salary of $2,250 and it is claimed by the 'retrenchment' members of the council that a capable official can be secured at a less figure. No notice has been served on City Engineer Johnston that his services are no longer required."

The rank injustice and the cold-blooded commercialism of the eight Kitchener councillors as expressed in this newspaper report are so obvious that comment is almost superfluous. Their action savors more of Berlin than of Kitchener.

The affair deserves the prompt attention of the council of the Canadian Society of Civil Engineers. The names of these eight councillors, if they do not withdraw from their position, should be made known to every engineer and to all other professional men in Canada. We cannot imagine any advantage that would accrue to professional men in dealing with individuals who would lend themselves to such contemptible tactics.

Mr. Johnston, who is a corporate member of the Canadian Society of Civil Engineers and an S.P.S. alumnus, has been in Kitchener's engineering department for fourteen years,—seven as assistant engineer and seven as city engineer. He has never previously had any serious disputes with any of the various councils, and none of his work has been under fire. He has not been asked by the councillors for his views on this subject, and in fact has not been approached by them in any way. They did not even enquire whether he would consent to a reduction in salary.

The whole affair is no doubt the result of an effort to keep the tax rate at a lower figure than can be done with efficiency in the city service. After the hospital, the school board and other Kitchener institutions had been made to suffer, it was still necessary to reduce expenses by a couple of thousand dollars more, so one alderman moved that the city engineer's salary be reduced by $1,100. As a result of the following discussion it was decided to advertise for "a cheaper engineer."

It is almost unnecessary to call to the attention of the engineering profession throughout Canada that it would be most unethical and unprofessional for any engineer to answer Kitchener's call for applications while Mr. Johnston still holds the position, or if he is discharged merely because a "cheaper" man is wanted. No self-respecting engineer will pay any attention to Kitchener's call.

SULPHUR IN ROAD OILS.

One of the four main requirements in the Canadian Society of Civil Engineer's tentative specifications for road oils reads as follows: "It shall not contain acid nor sulphur in sufficiently large quantities to attack rubber or rubber compositions."

At first glance such a clause appears to be a praiseworthy effort to reduce the cost of high living for tire-buying motorists. But the thoughts occurred to us upon reading these specifications, "What quantity of sulphur is sufficiently large to injure rubber or rubber compositions under the conditions of contact of auto tires with road oils? and should not a fixed maximum quantity be definitely stated in the specifications? and are there any active sulphur or sulphuric acid compounds in road oils?"

With these questions in mind, the views of several chemists and tire manufacturers were obtained, resulting in the conclusion that the Society would be well advised to discuss thoroughly the wording of this clause in their official standard specification. The specification has not yet been adopted by the Society, nor is it in any way recommended by the Society for use by the Society's members. It is as yet merely a tentative specification which was laid before the Society at its last annual meeting and received but not adopted. The committee that prepared it requested that it be merely received as they wished to report further at the next annual meeting. The tentative specification was offered meanwhile practically as a progress report. The following opinions upon the sulphur and acid requirement will therefore prove timely:—

A. F. Pond, chief chemist, Goodyear Tire & Rubber Co. of Canada, Limited: "It is our opinion that sulphur in an asphaltic road oil will have no injurious effect upon automobile tires."

W. E. Campbell, chief chemist, Gutta Percha & Rubber, Limited: "I do not think that the sulphur contained in road oils would be any danger to tires. Any injurious effect that road oils have upon tires comes more from the softening action of the oil on the rubber, and any vulcanizing or hardening effect of the sulphur would be offset by this softening. But even the softening action is not great enough to be at all serious unless the auto stands for a considerable period in a pool of oil. I do not think that any active injurious compounds of sulphur would be found in the oils in view of the temperatures at which they are refined."

The chief chemist of another large rubber company requested that his name be not published, but says: "My opinion right along has been that no amount of sulphur that would be found in any road oil on the market would damage auto tires. Free sulphur already exists in tires. Almost any rubber goods has a bloom. That's sulphur. We mix in 2, 3 or 5 per cent., or whatever may be called for by the requirements, and possibly only half of this will be used in the manufacturing processes, and the other half remains in the tire as free sulphur, but it doesn't do any harm to the tire. One can scrape sulphur off the surface of almost any piece of rubber goods two or three years old. At all times there is as much free sulphur on

the tires, forming a constituent part of the tire, as would be taken up off the road from a road oil. As for sulphuric acid, the refining processes tend to neutralize any such acid in the oils. But even a little sulphuric acid would not injure tires appreciably. The little bit of acid that would remain on the road after rainstorms, etc., would not 'touch' the tires."

C. A. Mullen, director of paving department, Milton Hersey Co., Limited, chemists and inspectors: "In reply to your enquiry for our opinion as to the effect that the small percentage of sulphur in asphaltic road oils might have upon the rubber in automobile tires passing over roads treated with such oils, we do not believe there would be any effect, and consider the suggestion that there might be as very far-fetched."

A. W. Dow, of Dow & Smith, chemical and paving engineers: "From long practical experience with oils containing sulphur, on roads, and also from laboratory examination, and from a theoretical consideration of the subject, we can positively state that the sulphur contained in road oils has no action whatsoever on rubber tires or rubber compounds.

"If the sulphur in the original oil was in a condition to act on rubber, this property would be entirely destroyed in the course of refining the oil. Any sulphur or sulphur compounds that will attack rubber will also attack the hydrocarbon oils when heated with them at a high temperature. In the process of manufacturing the asphalt road oils they have been heated to such a temperature that all active sulphur or sulphur compounds have been destroyed and rendered inert so that any sulphur that remains in the road oil has absolutely no action whatsoever on rubber or its compounds.

"The writer, while connected with the United States Government in Washington in 1914, made quite extensive tests on the action of road oils on rubber tires and pure gum rubber. Among the oils tested was a crude oil from Beaumont, Texas, oil field, containing considerable sulphur, some of which was evidently in a free state. After a test extending over six months he could not note that this oil had any more deleterious effect upon rubber tires and gum rubber than had oils from California and Pennsylvania, which were quite free from sulphur and sulphur compounds. In fact, he was surprised at the slight action of the heavy road oils on rubber and rubber compounds. He did find that the crude Russian oil had more action on rubber tires than any of the oils from the United States.

"Any statement to the effect that the sulphur is contained in these oils as sulphuric acid is absolutely false, as sulphuric acid can not exist at temperatures much lower than those to which the oils have been subjected in the course of their manufacture. The fact that these oils are shipped in iron receptacles and are refined in iron stills should be sufficient evidence to show that such a statement is ridiculous.

"I have just inquired of the chief chemist of the United States Rubber Company, who are large manufacturers, if he has ever noted any deleterious effects of road oil on rubber tires, and if so whether he has noted that any one oil is more deleterious than another. He has just told me that he has never noticed any difference in the action of different oils on rubber tires, and part of his work consists in the making of special mixtures for tires and studying their wear under different road conditions."

A. E. Heyes, of Thos. Heyes & Son, consulting chemists: "The sulphur or sulphonates in road oil would not affect rubber tires. There would be no active sulphuric acid in such oils after refining. The only damage road oils would cause would be a tendency gradually to rot the tire and its canvas backing through softening. This would be very gradual and hardly need be considered for any practical purposes. If a tire were to be immersed in an oil bath and stood in the sun, then the oil would no doubt have an effect upon the tire. But it would require eight per cent. of sulphur to harden or crack tires, and even if this quantity were to be in the road oil, the nature of the contact of the tire and the oil is such that we do not believe there could be any injurious results from anything of this nature."

T. Linsey Crossley, of J. T. Donald & Co., consulting chemists and paving engineers: "Unless the road oil is badly placed, the oil will not get on the tire at all except on the tread, which would not be affected by the oil. The tread is either being continually rubbed off by the stone dust and sandy matter, or else, if the road is muddy, the mixture of water with the oiled earth will dilute it so much that there is still less chance of any damage. As a matter of fact, the tire troubles so often attributed to road oils are almost always due to other causes.

"Some oils are solvent and might affect a tire somewhat, but not a high grade asphaltic or tar oil. The cheaper, carelessly-prepared road oils would affect tires, but even there the damage is not due to sulphur but to the fraudulent use of acid sludge, i.e., the mixture of sulphonated hydrocarbons resulting from the treatment of bitumens with sulphuric acid. If any of this material should be sold by mixing to form a road oil, or should find its way into a carelessly prepared road oil, it might have a bad effect. The chief effect would be upon metal surfaces rather than on rubber, however.

"Sulphuric acids in straight steam-refined road oils would no doubt be eliminated by the refining processes. The sulphur that occurs in the crude oils is present as complex sulphur compounds of these oils, and not as H_2SO_4, or as H_2SO_3, and probably not even as H_2S.

"Chemically, road oils are very inert substances. Any action they would have would be physical, i.e., as solvents. And I do not think that the solvent effect upon tires would be noticeable. Even if one soaked a tire in road oil, it is doubtful whether that would have much actual effect."

The opinions of these well-known paving chemists, and of the tire manufacturers (who guarantee big mileages for their tires and would be bitterly opposed to any influences tending to damage them) are authoritative. Due consideration will no doubt be given to them by the committee reporting on this specification.

C.P.R. EXHIBIT OF HYDRO-ELECTRICS.

To emphasize the economic importance of electric products, and to show their relation to other industries is the object of the C.P.R. Hydro-Electric exhibit opened on March 12th in the Shaughnessy Building, McGill St., Montreal. The exhibit has been arranged to interest the layman as well as the specialists, and, although it is essentially technical in character, processes are explained so clearly in the accompanying placards that he who runs may read. An instance of this is the series showing the evolution of the modern incandescent electric lamp. An interesting item shown was a shell piercer punch with an actual record of having pierced 24,000 4.5-inch shells.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

HIGHWAY BRIDGES IN ONTARIO

REVIEW OF DESIGN AND METHODS OF CONSTRUCTION OF STRUCTURES ADAPTED TO THE REQUIREMENTS OF MODERN TRAFFIC CONDITIONS

By GEO. HOGARTH, A.M.Can.Soc.C.E.,
Chief Engineer, Department Public Highways, Ontario.

THE improvement of roads throughout the province has attracted a wide public interest for some years, and the superior type of road now built has led to a demand for better types of culverts and bridges with wide roadways, and an appearance in keeping with the improved surroundings. Among county officials there has been an increased interest in the types of construction selected. There still remains, however, a lack of uniformity in general construction, and an absence of proper appreciation of the many types of culverts which are suitable for the smaller waterways. It is, therefore, sought to present to those in charge of the highways a review of design and methods of construction which will result in securing sound and enduring structures properly adapted to the requirements of traffic in designing culverts and bridges to be built on the highways of the Province of Ontario.

A Substantial and Attractive Concrete Arch.

An Artistic Handrail.

Periodical Examination.—It is advisable that the county or township road superintendent should periodically, at least twice a year, examine all parts of each steel bridge under his care.

Location.—When a permanent structure is to be erected the site should be carefully selected so that there will be the least possible exposure to the forces tending to cause destruction of the bridge. The site should also be chosen so that the cost of construction will be as low as consistent with good service to the public.

The safety of the public demands that a bridge be located so that it is parallel with the centre of the road. To place it otherwise, at an angle with the road, will give a turn at each end which is dangerous and should be avoided.

Size of Waterways.—In selecting the size of a waterway careful consideration should be given local conditions, including flood height and flow, size and behaviour of other openings in the vicinity carrying the same stream characteristics of the channel and of the watershed, climatic conditions, extent and character of the traffic on the highway and other circumstances affecting the safety, economical construction or maintenance of the culvert or opening.

The use of a formula to assist in determining the proper size of waterway can only be warranted when the values of the terms in the formula are known to suit local conditions. Such formulas are useful as a guide in fixing and verifying bridge or culvert sizes where only general information regarding the watershed is available. A formula should not be used where it is possible for the engineer to visit the site and by careful examination of the locality arrive at a satisfactory result.

It is advisable to place the face of the footings of abutments at least as wide apart as the banks of the river, and still further apart if other circumstances warrant. Never place the abutments of a bridge in the water. Keep the abutments on the shore with their front at the water's edge.

Bridges.—Many timber bridges still exist in the older parts of Ontario, and these structures are a heavy burden to the municipality in which they are situated. They require constant attention and frequent repairs to keep them in a safe condition for public travel.

In addition to the expense for maintaining such bridges they are a source of anxiety to municipal officials, as such structures frequently collapse, as the accom-

*Abstracted from pamphlet concerning the construction of highway bridges recently sent out simultaneously with and supplementary to "General Plans for Highway Bridges."

panying illustration shows. In this case the driver of the threshing engine knew before reaching the bridge that it was unsafe, but hoped to cross safely by running rapidly. The bridge fell when the full weight of the rear

A Timber Bridge after Collapse.

wheels of the engine came on the centre floor beam and the machine went down in four or five feet of mud and water.

Foundations.—The word "foundation" in this article means the natural bed of material upon which rest the footings of the piers or abutments. This material may be muck, silt, sand, gravel, clay, boulders, rock, an artificial timber foundation of logs or other material, or it may consist of piles driven to support the structure.

For the smaller structures, such as pipe and box culverts, carrying the customary highway loads, the ordinary earth foundation is usually sufficient, but care must be exercised to provide protection against the undermining of the foundation by running water. Where the ground is very wet and soft or in swamps it may be necessary to increase the supporting power of the soil by placing logs 10 inches to 12 inches in diameter and about two feet apart under the footing and parallel with the roadway. These logs should extend entirely under the culvert, and should be four feet longer than the distance out-to-out of the footings. The advantages of such a type of footing are that the logs distribute the weight

Handrail of Concrete Arch.

of the culvert and so prevent uneven settlement and tipping of the end and sidewalls.

Footings.—Footings of piers, abutments and headwalls should be carried down below the surface of the ground or the bed of the river to such a depth as to be safe from the heaving effect of frost and scour of the water. In the southern portion of Ontario the effects of frost may extend to depths of $2\frac{1}{2}$ feet, while in the north it may vary from $3\frac{1}{2}$ to 4 feet.

Piers.—Where a bridge is required of over 100 feet span it may be economical to consider using two or more short spans of about 50 feet, and support their ends by placing a pier in the river.

Whether this type of construction is economical or not depends upon the cost of the various spans, and also upon the size and cost of the pier or piers required. Where a river can be crossed by using a single span it is very often undesirable to use piers, as they furnish an obstruction to the waterway, and are liable to be damaged or destroyed by ice jams, logs, driftwood or floods. The kind of foundation available for the pier may also be a controlling factor in the design of the bridge, and should the river be very deep or have a soft, shifting bottom the use of piers may not be economical.

The size of piers is usually governed by the width of the top of the pier required to support the bearings of the bridge. This width may be from 3 to 5 or 6 or more feet. A coping having a width of about 3 inches and a height of 1 foot or more, depending on the height

Steel Lattice Handrail.

of the pier, is placed around the top of the pier, and the shaft of the pier then given a batter of from 1 in 12 to 1 in 24 from the under side of the coping to the top of the footing. The width of footing depends to some extent upon the nature of the foundation, but if it is extended for from 9 inches to 1 foot all around the pier, a satisfactory size will usually be secured.

On the upstream side of the pier a wedge-shaped cutwater or starling is usually provided to deflect the water and debris. As additional protection a steel plate or steel angle 8 inches x 8 inches x $\frac{1}{2}$-inch in section may be built into the nose of the starling, and should extend from a point several feet above high water down into the footing. This steel angle should be secured to the pier by $\frac{3}{4}$-inch rag bolts, 12 inches long, having countersunk heads and spaced about two feet apart on centres.

The footings of piers should be carefully constructed, and if there is any possibility of the river scouring the foundation, a quantity of stone should be placed around the outside of the footing as a protection. Where possible the footing of a pier should not be placed upon a foundation which is liable to be softened, scoured or undermined by water action or on a hard strata, when overlying softer material.

Footings of piers should be embedded in firm ground to a depth of not less than four feet, in order to make

the pier secure against displacement. The entire design of a pier should be carried out so that it will have a stability factor of at least two under all possible conditions.

Roadway Embankments.—The embankments of the approaches to a bridge should be made in thin layers and thoroughly compacted. Each layer should be built out to the full width required, with its sides constructed to the true slope, and not widened with loose material dumped from the top. All side slopes of the embankment should be constructed to a batter of $1\frac{1}{2}$ feet horizontal to 1 foot vertical.

Where washing of the embankment may be expected during times of high water, the outside slopes should be protected with a rip rap of large stones properly laid to protect the filling. Such rip rap should extend from a solid bottom up to a height of several feet above high water mark.

Surface and Subsurface Drainage.—Wherever possible water shall be kept off the roadbed. This may be accomplished by a properly crowned roadway surface, and by having the ditches always in proper condition to drain water away. Water should not be allowed to remain in side ditches, and to prevent such condition the

Handrail Should be of Such Height as to Give Confidence.

ditches should be properly graded to the natural outlet. To protect embankments built upon saturated soils a satisfactory procedure is to provide intercepting ditches or pipe drains. In cuts, the side ditches should be excavated through whatever class of material is met with. In wet cuts or in wet and soft hills or side hills a tile drain or drains should be provided. The wet spots appearing in the roadway on a hill should have a tile drain run into such wet spot, and any soft material removed and replaced with crushed stone or gravel.

Breaking and sliding away of the shoulder of a roadway is best cured by flattening the slope away from the shoulder. This should be accomplished by filling in material against the embankment. The old surface of the embankment should be ploughed before any new material is placed, so that a satisfactory bond may be secured.

Where a roadway is in a cutting and material from the sloping banks continues to slide in on to the road, the best method of securing relief is to remove the bank on each side of the road till a flatter slope is secured.

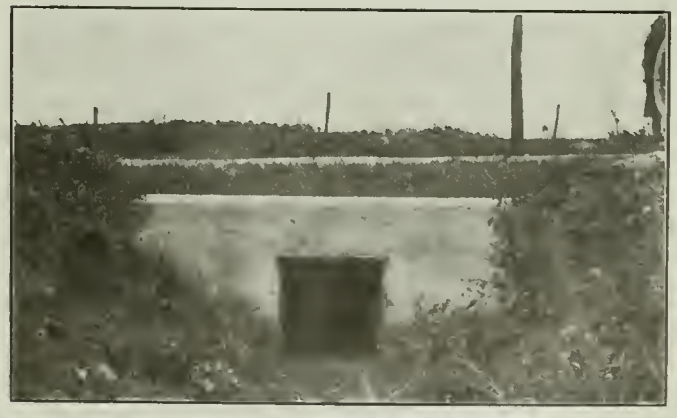
Pipe Culverts.—Pipe culverts are circular in cross-section, and vary from 8 to 48, and even 60 inches in diameter. The materials used in their manufacture are vitrified clay, corrugated sheet metal, cast-iron and concrete. Culverts should be permanent; should be large enough to easily pass the largest flood flow of water; should, if possible, be self-cleaning, and should be of such a size as to permit cleaning.

It is important that they be large enough to enable proper cleaning, and with this fact in view it is recommended that pipes less than 15 inches in diameter be not used, and that the opening of box culverts be not less than 2 feet square. The amount of material required for these sizes is not a very great increase over those of smaller dimensions, and the ease with which they may be maintained fully warrants their construction. Where conditions permit, culverts should be laid with a fall of about 1 foot in 20 feet, and care should be taken to see that the ditch above and below the culvert is properly graded to deliver and carry away the water.

What Happens when Good Endwalls are not Used and Pipe not Properly Located.

Care should be taken to construct a substantial headwall of concrete or rubble-stone at each end of the pipe, and to see that the footings of this wall extend to a depth of not less than 3 feet. All joints in the pipe should be carefully made and thoroughly tight.

The foundation upon which the pipe rests is very important, and a solid bottom should be secured before laying the pipe. If earth is the material upon which the pipe is laid a satisfactory foundation may be secured by trimming off the bottom of the trench to a firm and even bearing. After the pipe is placed great care should be taken to thoroughly tamp and pack the backfilling around



Well Built and Properly Drained.

the pipe, as otherwise unequal settlement may occur and the earth will crack or crush the pipe. Backfilling should be placed in layers 6 inches thick and well tamped. In soft or marshy soils a trench should be excavated one

foot below the proposed bottom of the culvert and refilled with coarse gravel or broken stone.

Length of Culverts.—Culverts are frequently constructed of an insufficient length so that the fill spills over the top of the coping. For pipe and box culverts on county roads the distance between the inside edges of endwalls should not be less than 24 feet where the top of the culvert is about 1 foot below the crown of the road. For cases where a culvert is placed in a fill, the proper length of barrel is obtained by adding together the width of the roadway, three times the height of the crown of the road above the top of the culvert and twice the thickness of the coping wall.

Handrails.—Handrails on all structures should be at least four feet in height above the top of the floor of the structure, and should be designed to safely support a load of 60 pounds per lineal foot applied laterally at the top of the handrail. Handrails may be of steel lattice, galvanized iron pipe or concrete.

It is, therefore, not advisable to use bank run gravel in concrete. A much better practice is to screen the gravel, and after obtaining the sand and pebbles in separate piles to combine the ingredients for concrete by selecting two parts sand and four parts pebbles, or using them in any other proportion which may be desired. The resulting concrete will be of much better quality and the slight extra expense for screening will be repaid in the quality of concrete secured.

Specifications and Inspection.—Proper specifications should be prepared for all structures, and during construction an inspector should be employed to see that the provisions of the specifications are observed. Carelessness in proportioning a few batches of concrete or the accidental omission of the cement may cause failure of the bridge.

ANNUAL MEETING OF JOINT COMMITTEE OF TECHNICAL ORGANIZATIONS.

The Joint Committee of Technical Organizations, under the chairmanship of Alfred Burton, met in the Mining Building of the Toronto University March 30th to discuss and adopt the first annual report of the organization.

Captain Matheson, who has been seventeen and one-half months in the trenches, declared that upon the mental, physical and professional efficiency of the sappers in the field the success of British arms in France was dependent to a very significant extent.

Mr. R. A. Ross, who is a member of the Advisory Committee on Scientific and Industrial Research, spoke of the assistance which had been called for and received in good measure by the French, British and Canadian Governments from the organized classes of engineers, and he was sure that the joint committee of Ontario Technical Organizations would grow in importance and rapidly assume national scope. He believed that the engineers should come out from their professional retirement and take a more active part in the political affairs of the country and exercise the same quality of efficiency in the administration of internal matters as they had displayed in their contributions to the strength of the Empire in the present struggle.

The machine tool exports from America during the year ending June 30, 1916, are said to have exceeded $61,000,000, of which about $48,000,000 left through the port of New York. This is more than twice the amount of similar exports for the previous year.

BEST PRACTICE IN WOOD BLOCK PAVEMENTS.*

By Ellis R. Dutton,
Assistant City Engineer, Minneapolis, Minn.

PAVEMENTS are almost as old as people. When people began to be civilized and neighborly, then began the need of a better means of communication, and, as needs increased, methods were put in force to alleviate those needs—and invention, you might say, was called upon. The rough trail was smoothed and the wet places were filled and bridged so that a better means of communication was provided. As time went on, and the methods of transportation were improved, a better road was required and a surface that would permit of communication in all kinds of weather. This was provided by the use of broken stone of larger dimension and of greater depth. The remains of the old Roman roads are seen to-day and show how well they builded, but these roads would not only be costly in these days, but they would be useless under the modern methods of transportation. Stone, however, of some form has been used in the construction of pavements from time immemorial and probably will continue to be used indefinitely in some part of the work.

The use of wood as a paving material did not begin until recent years—and then it was not successful on account of its rapid deterioration. It was used in London and New York in the early thirties of the 19th century, and somewhat later on the continent. These pavements were rough, or soon became so, and the improvements were along the lines of a smoother pavement, which resulted in the so-called "Nicholson" pavements laid quite extensively about 40 or 50 years ago. This pavement fulfilled the desired smoothness but did not last, as the wood was untreated and permitted water to enter and the blocks soon decayed. There was also tried in this country, and particularly in the west, the round cedar blocks. The triangular intestics between the round blocks soon permitted travel to also round the *top* of the block, making the surface very uneven and rough, and reminding one of the old corduroy roads. Decay also played havoc with the blocks—and in a very short time this pavement had gone the way of its predecessors and some other class of pavement had to be used.

About this time attention was turned to some examples of wood which had been treated with dead oil of coal tar and used for paving purposes. One example was in Galveston, Texas, where some creosoted pine blocks were laid in 1873. Another was in New Orleans, where similar blocks were used; also in St. Louis, in 1877. The extended use, however, of this class of pavement did not begin until about the beginning of the 20th century; and then its advocates had to overcome the prejudices that had arisen on account of the previous use of untreated wood. It was, however, recognized that if wood could be preserved from decay, it would make a better pavement in many ways than any other kind of material.

One of the earliest pavements of this material, in the middle west, was laid in Minneapolis in 1902, which has made a record as to durability and low cost of maintenance—and from present appearances it will be good for quite a number of years. There are numerous examples throughout the country of as good, if not better, record; one right here in the city of Boston, laid I think, a year or two prior to that in Minneapolis. Last year I had the

*Paper read before the American Road Builders' Association, Boston, Mass.

pleasure of inspecting with Mr. Geo. W. Tillson (the engineer who laid them) some creosoted wood block pavements in the city of Brooklyn. These were laid in 1900, and they were in excellent condition. From these beginnings the industry has come to the present time through many experiments, changes and improvements, to the present-day practice. Some things that were considered in the early days of the industry of little importance have proven to be of vital import; and other things formerly considered *the thing* have been relegated to the discard.

One of my first experiences along these lines was, when in the treatment of some blocks in 1903, the sap-wood showed a penetration of the preservative of only half an inch or so. I did not think that it was sufficient, but the "expert" said the oil would penetrate further as the block aged, and that *he* would guarantee it to be preserved. Well, the results show that the oil was insufficient; that it did not penetrate any further; that the blocks were not preserved, and that the "expert's" guarantee and the blocks were rotten. So we had to learn something ourselves and not depend on the so-called expert opinion of interested persons. Since investigating, studying and applying knowledge gained, we have had no such results, and we have learned that the oil has to be put into the wood if you wish to preserve it.

Another fallacy of the early days was the idea that you had to extract all the resins, etc., from the wood before treatment; and certain methods of steaming were resorted to, to accomplish this result. The fact of the matter is, no such results, as intended, were accomplished, but inadvertently a result was accomplished which in the later days is considered quite necessary; that is, the expansion and drying or seasoning of the blocks by steaming. This feature, the proper preparation of the blocks before the introduction of the oil, and the proper treatment of the blocks after the introduction of the oil, is now considered a matter of prime importance—and the quality of the oil is more of a secondary matter.

For a number of years the oil was the whole thing and there was a great diversity of opinion as to the best oil to be used; whether it was a heavy oil, or a light oil, or a tar oil, or a distillate oil; whether it was a coal-gas tar oil or a water-gas tar oil. It has been found that there are quite a number of oils or tars that are suitable to be used, and any one of them will preserve the wood and make a first-class paving block. The statement has been made that oils used in about 1908, when the gravity of the oil was raised from 1.08 to 1.10, would not be stable and remain in the blocks and would not preserve them. We took from the street, in the fall of 1916, some of the blocks treated in that year (1908) and extracted the oil to see what changes had occurred in the oil. From the comparison with the original oil, it shows that the residue originally above 355°, was 49 per cent.; in the extracted oil it was 52 per cent. The gravity of the original oil was 1.10, and of the extracted oil 1.116. The amount of oil per cubic foot in the original treatment was 16 pounds; and from the sample from which the oil was extracted it was about 12 pounds, showing that there had probably been some loss; but that there was plenty of oil remaining to insure its preservation for a number of years. There was no indication of any decay or anything of that kind noticeable in the pavement, so that the theory that the oil had evaporated or did not preserve the wood, was false.

Almost all of the engineers and wood-preserving experts agree in recommending a heavy oil of a gravity of 1.08 to 1.12, and the majority recommend a coal-tar oil, though they do not discourage the use of a distillate oil except as to the cost and use of a less amount of oil than 16 pounds per cubic foot.

There was a committee of the American Wood Preservers' Association which have been investigating the claim of the water-gas tar producers as to the preserving properties of their material. They cited numbers of places where wood paving blocks treated with water-gas tar had been used successfully. From the personal investigation of the committee, as shown in the report as presented to the meeting of the association held in New York in January, 1917, it would appear that "refined water-gas tar has demonstrated its value and usefulness as a preservative for wood paving block." (pp. 47, Advance Copy of Committee on Preservatives.)

There has been, however, considerable progress made as to the method of treatment which has done more toward making a better block, than along the oil lines. Under the old methods, difficulties and objections arose after the pavement was laid, on account of swelling, bleeding, etc. These objections were directly traceable to the method of impregnation. Experiments and tests were made to improve the progress, and the improved method now advocated provides that the blocks be steamed from 2 to 4 hours before the vacuum is applied. This vacuum should be at least 22 inches and held for at least one hour. The preservative oil is then run in without air being admitted, and pressure gradually applied until the required quantity has been forced into the blocks. After this, a supplemental vacuum of at least 20 inches shall be applied for not less than 30 minutes. If necessary, the vacuum may be preceded or followed by a short steaming process.

This is the specification as adopted by the various societies having to do with such matters. This treatment produces a block in which the oil has thoroughly penetrated the sap-wood and the interior of the block—and leaves the outside clean and dry so that there is almost no bleeding.

We laid a section of paving blocks treated as above, in 1915, in which a part was filled with the ordinary pitch filler and a part was filled with sand, to determine actually whether blocks so treated did bleed. We found that the part filled with sand showed almost no bleeding, only a block here and there showing oil on the surface, while the bituminous filler used on the other part caused almost all of the so-called bleeding. There have been some misstatements made as to this experiment, and attributing the bleeding to the use of a coal-tar pitch filler. Such is not the case, as any bituminous filler, either pitch or asphalt, would cause the same result. If some material could be provided which would eliminate this feature and still preserve the good qualities of the bituminous filler, it would be a great benefit to the wood block industry, and incidentally to the person introducing it.

Creosoted wood block paving, in this country at least, has been usually laid on a sand cushion of approximately one inch in thickness, spread on the top of the concrete foundation. There have been a large amount of successful pavements laid in this manner, but there has been also quite another large amount that has not been so successful. If the right quality of sand be used properly, it is all right, but under most systems of doing work, it would be better to use some other method. Probably the best practice to be followed is to make a smooth surface, true to grade and contour, on the concrete foundation, when it is laid. Immediately before the laying of the blocks, this surface is painted with a thin coating of bituminous material of the proper consistency. The blocks are then laid on this bituminous coating, to which they adhere, and the joints are filled with the usual material.

This differs from the European and Continental practice, where the concrete is made smooth, but the blocks are dipped in the bitumen and then laid on the concrete. I examined an interesting example of a pavement laid in the first method outlined above, on Dawson Road, a highway leading out from the city of St. Boniface, near Winnipeg, Canada. This work was done in 1910, using a Norway pine block 3 inches in depth and treated with 16 pounds of heavy oil. There were several brick yards that used the pavement in hauling their products to town, and also the country travel in and out. The street had no care or maintenance, and no sprinkling had been done to keep the blocks from drying. At the time of the investigation in 1916, the pavement was in good condition and showed no evidence of bleeding or swelling; the curb along the edges being true and straight as they were when placed.

In the earlier days of the industry it was considered necessary to provide expansion joints at right angles to the curb line, and to lay the blocks at right angles. These expansion joints were found to be a source of weakness to the pavement and also to be of no use, so they have been discontinued. It is still an open question as to whether the blocks be laid at right angles to the curb or on some other angle. In the experimental pavement laid in Minneapolis in 1906, there were three contiguous sections laid; one at 90°, one at 67½° and one at 45°. From the several inspections of these sections it is quite apparent that the blocks laid at 67½° and 45° show less trouble from joint wear than those at 90°. These blocks were Norway pine and would show the wear much faster than a harder pine.

There has been considerable discussion as to the effect the steaming required in the new specifications, as above outlined, would have on the crushing strength of the blocks. Experiments have been made by the Forest Service, and a paper by Mr. Clyde R. Teasdale, giving the results of such tests was presented to the American Wood Preservers' Association at its recent meeting in New York. From these experiments, there does not appear to be any weakening of the crushing strength of the blocks by such treatment. Treated green heart pieces gave average results 3.5 per cent. below the corresponding natural pieces; treated green sap pieces, about 1 per cent. higher than corresponding natural pieces; treated air-dry heart pieces, 10 per cent. higher than natural pieces; and treated air-dry sap pieces, 8.5 per cent. higher than natural pieces.

The value and usefulness of a pavement depends largely on the cost of its upkeep, and a pavement where the repairs are low is the better, all things being equal. There have been numerous inquiries as to the cost of repairs on a creosoted wood block pavement. The following is the cost in cents per square yard per year for repairs, to creosoted wood block pavements in Minneapolis for the various years, and also shows the total yardage in place on January 1st of each year:

Year.	Total square yards.	Maintenance, cents per sq. yd.
1907	210,464	0.012
1908	312,815	0.085
1909	457,583	0.052
1910	600,922	0.064
1911	757,472	0.294
1912	928,726	0.162
1913	1,060,688	0.193
1914	1,195,932	0.254
1915	1,381,605	0.239
1916	1,516,819	0.054

The average cost of repairs in the 10th Street paving laid in 1902, for the past 10 years has been about 1 10th of a cent per square yard per year. From these figures you can readily see that the maintenance or upkeep cost is very low and that this class of pavement fullils the requirements of a first-class pavement as to cost of maintenance; and there is no question as to its exceeding all others as to its noiselessness and traction resistance.

There has been in times past, a great deal of controversy over various things to do with the materials and manufacture of creosoted wood blocks. It is very gratifying, indeed, to see these things being overcome, and a better feeling of unity prevailing as to the disputed points by all parties, so that now they can agree on a uniform standard specification.

This adoption of a standard specification does not mean that we have learned all there is to know about creosote or wood block pavements. There is just as large a field for investigation, experiments and improvements as ever, and we should be all the better prepared, by reason of the accumulated knowledge, to go forward and make and maintain wood blocks as the best pavement known.

RESISTANCE OF PASSENGER TRAIN EQUIPMENT.*

By E. C. Schmidt and H. H. Dunn.

CONTINUING the work on train resistance which it has been carrying on since 1907, the department of railway engineering of the University of Illinois has recently completed a series of tests undertaken to determine the tractive resistance of moderately heavy passenger trains. The tests were begun in May, 1916, and finished in August. Through the courtesy of W. L. Park, vice-president of the Illinois Central, they were made on the lines of that company between Champaign, Ill., and Centralia, on trains in regular through passenger service, and by means of a dynamometer car. The results of the tests prove that in passenger trains, as in freight trains, the specific resistance is materially affected by the weight of the cars composing the train, and that it decreases as the average weight of the cars increases.

The Trains Tested.—The trains experimented upon —18 in number—were all passenger trains, which varied in total weight from 535 to 727 tons. The number of cars varied from eight to twelve. The train make-up was not uniform and is shown for each train in the table. The average gross weight per car in the various trains ranged from 48.7 to 71.1 tons. In 13 of the 18 trains the dynamometer car was coupled with its measuring drawbar toward the rear, and in these cases its own resistance is excluded from the test car records; its weight is consequently likewise excluded from the train weights listed in the table. In the five remaining trains, on the other hand, the resistance of the dynamometer car itself is included in the records and its weight is therefore included in the train weight. Since the test car weighs only 29 tons, the normal average car weight is somewhat lowered in these five instances. All but 32 of the 187 cars included in the 18 trains had six-wheeled trucks. Other data defining the train make-up are given in the table.

*Abstract from Railway Age Gazette of a paper published in Bulletin 194 of the American Railway Engineering Association.

All the northbound trains were "No. 2 Through Mail," whose schedule for the 124.5 miles is 3 hours and 5 minutes—a schedule speed of 40.4 miles per hour. The running time of a typical northbound train is 2 hours and

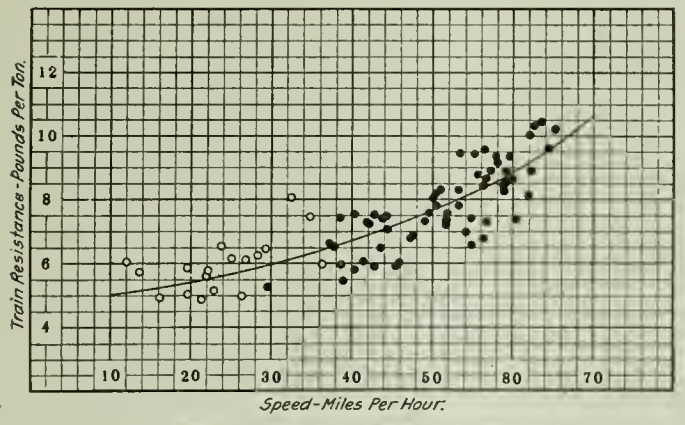


Fig. 1.—Relation Between Resistance and Speed for Test 44B.

37 minutes, which is equivalent to a running speed of 47.5 miles per hour. The southbound trains, "No. 5 Fast Mail," have a schedule of 3 hours and 35 minutes, or a schedule speed of 34.8 miles per hour. A typical running time for this train is 2 hours and 51 minutes, which gives an average running speed of 43.7 miles per hour.

Track and the Weather Conditions.—The roadbed on which the tests were made was in good condition and the drainage, in general, was excellent. The track was especially surveyed for the purposes of these tests. Except on a few short stretches through station grounds, where cinders and screenings are used for ballast, both tracks are ballasted with broken limestone. The cross-ties, 6 ins. by 6 ins. by 8 ft., are spaced about 20 ins. between centres and are of treated red oak, treated soft wood or untreated white oak. Sixty-one miles of the southbound track are laid with 85-lb. rail of American Society of Civil Engineers section, while the remaining 63.5 miles are laid with 90-lb. rail of American Railway Association section. Practically all of the northbound

Test Number	Average Approximate Wind Velocity Miles Per Hr	Gross Train Wt. Tons	Cars in Train	No. of Cars Having Three Axles Per Truck	Kind of Cars: Test Car	Baggage and Express	Mail	Coaches	Pullmans	Diner	Special
44A		604.5	11	9		6	2	2	1		
44B		570.0	11	9		6	2	2	1		
46A	20.0	615.48	11	9		4	4	2	1		
46B	15.0	551.32	10	8		3	4	2	1		
47	10.0	727.0	11	10	1	1	1	3	4	1	
48A		538.5	11	9		5	2	2	1		1
48B		562.0	11	8		6	2	2	1		
49A	20.0	588.2	9	8	1	1	1	2	3	1	
49B	20.0	634.9	10	8	1	1	1	3	3	1	
50A	25.0	601.6	12	9	1	6	2	2	1		
50B	25.0	535.2	11	8	1	5	2	2	1		
51A	20.0	618.01	9	8		1	1	3	3	1	
51B	20.0	549.02	8	7		1	1	2	3	1	
52A	20.0	570.1	11	9		6	2	2	1		
52B	15.0	540.0	11	9		5	2	2	1		1
53A	15.0	708.3	10	9		1	1	3	4	1	
53B	15.0	639.92	9	9		1	1	2	4	1	
54	20.0	606.23	11	9		6	2	2	1		

Description of Cars.

track is laid with 85-lb. rail of American Society of Civil Engineers section. All rails are laid with broken joints supported on two ties. During eight months of the year there is employed in maintaining this portion of the road, a force of men averaging one man per mile of track. During the remaining four months this force is reduced to one man for each two miles.

The tests were all made on fair summer days, the air temperature which prevailed during the tests varying from 69 degrees to 93 degrees Fahrenheit. The wind velocity varied up to 25 miles per hour.

Test Methods.—The apparatus within the dynamometer car used produces continuous graphical records of the gross resistance of the train, the speed, time, brake cylinder pressure, wind direction and wind velocity. The net weights of all cars were obtained from the records of the Illinois Central and the Pullman Company. To determine the car loads, passengers were counted and allowed for at 140 lbs. each; the weights of baggage and mail were estimated by personal inspection and count of the contents of each car; the weight of express was determined by reference to the bills, supplemented by inspection and estimate. The maximum error in the gross train load itself caused by the processes described is less than 1 per cent.

All resistance values here presented have been corrected for grade and for acceleration, and they denote,

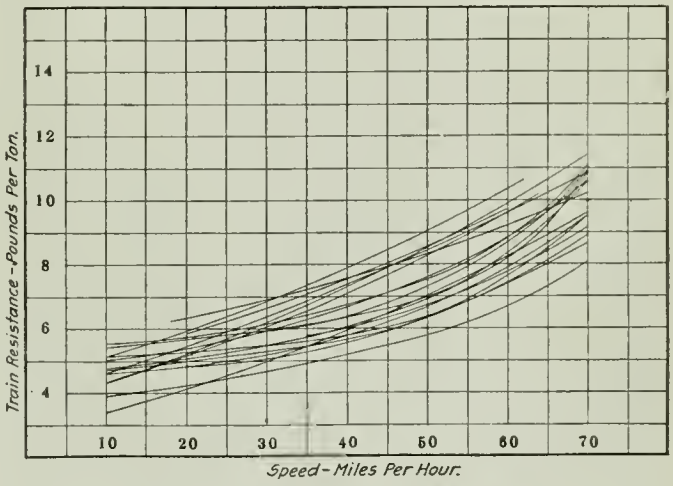


Fig. 2.—Relation Between Resistance and Speed for the 18 Trains Tested.

therefore, the resistance of the train when running at uniform speed on level track. The data do not permit the resistance due to wind to be differentiated and this element of resistance is consequently included in the values presented. Unless otherwise stated, these resistance values are expressed in terms of pounds per ton of gross train weight.

Test Results.—The immediate purpose of the tests was to define for each train the relation between net resistance and speed. On the dynamometer car records for each train there were accordingly chosen a number of points or sections corresponding to as great a variety of speeds as the data presented. At each section the net resistance was calculated and the calculated value with its corresponding speed was plotted on a diagram such as Fig. 1. The curve there drawn establishes for the train in question the average relation between resistance and speed. Fig. 1 is fairly representative of the eighteen such diagrams produced during the experiments. In this figure the black dots define average value of resistance during the passage of the train over several hundred feet of track at a uniform speed; the circles define instantaneous resistance values as the train passes a particular point on the road. In this manner there has been pro-

duced for each of the eighteen trains tested a curve, like that drawn in Fig. 1, which has been accepted as defining the relation between resistance and speed. All eighteen of these curves are brought together in Fig. 2,

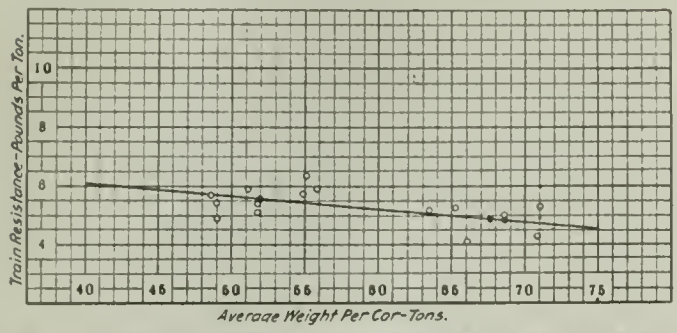


Fig. 3.—Relation Between Resistance and Average Car Weight at a Speed of 20 Miles per Hour.

which embodies therefore the immediate results of all the tests.

Inspection of Fig. 2 reveals a considerable divergence among the curves there drawn. At 20 miles per hour, for example, the values of resistance vary from 4.1 to 6.3 lbs. per ton, and at 70 miles per hour the values of resistance range from 8.0 to 11.4 lbs. per ton. While a study of the conditions prevailing during the tests provides in a few instances other partial explanations for this divergence, it is chiefly due to the differences in the average weights of the cars composing the different trains. Those trains composed of relatively light cars have the higher resistance (expressed in pounds per ton), whereas trains of heavy cars have a low specific resistance. This fact is better established by the process described below.

If in Fig. 2 at the point corresponding to 20 miles per hour a perpendicular is erected, it will cut the curves in eighteen points, each of which pertains to a particular train and defines for that train the average value of resistance at a speed of 20 miles per hour. If each of these resistance values are plotted with respect to the average car weight of the train to which it pertains, the diagram shown in Fig. 3 is obtained. It is obvious that as the car weight increases, the specific resistance decreases. The average rate of this decrease is shown by the straight line.

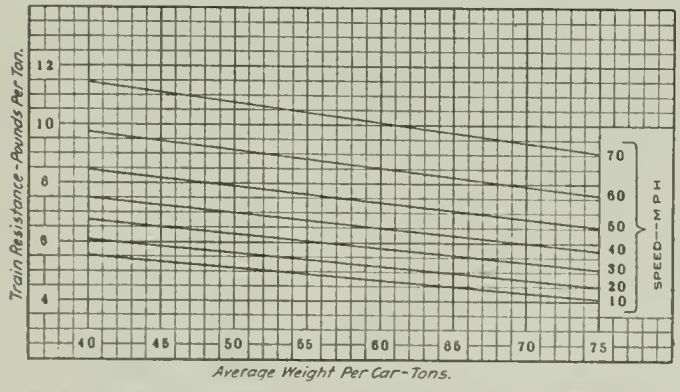


Fig. 4.—Relation Between Resistance and Average Car Weight at Various Speeds.

By a similar process, six other such straight lines have been determined defining this relation at speeds of 10, 30, 40, 50, 60 and 70 miles per hour. These six lines, together with those from Fig. 3, are all brought together in Fig. 4, which shows the average relation between resistance and car weight for each of seven different speeds. This figure, however, presents the relations in unusual form and Fig. 5 has been drawn from Fig. 4 to show a corresponding group of resistance-speed curves.

The relation between the two figures will be made clear by explaining the derivation of the upper curve in Fig. 5—the one applying to a car weight of 40 tons. In Fig. 4 the ordinate corresponding to an average car weight of 40 tons cuts the seven lines there drawn at seven points at which the mean resistance values are 5.5, 6.1, 6.7, 7.5, 8.5, 9.7 and 11.5 lbs. per ton, corresponding to speeds of 10, 20, 30, 40, 50, 60 and 70 miles per hour, respectively. These values are the co-ordinates of seven points on a resistance-speed curve applying to a car weight of 40 tons. These seven points have been plotted in Fig. 5 and define there the upper curve.

As these results are all derived from curves such as that drawn in Fig. 1, one must expect to encounter as much variation from the average values as is indicated in this figure. It should be borne in mind that they apply

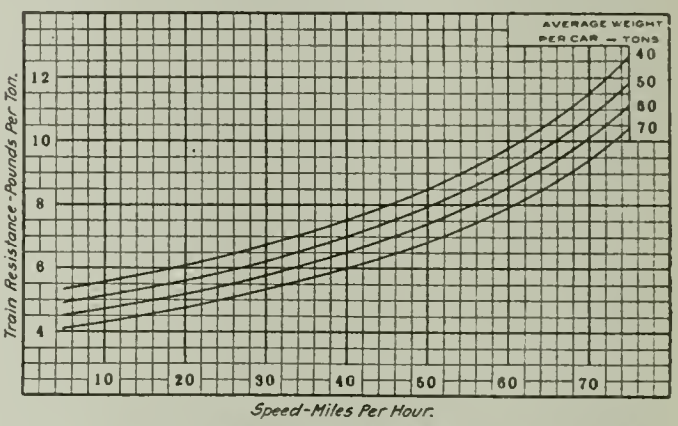


Fig. 5.—Relation Between Resistance and Speed for Cars of Various Average Weights.

to trains running on level track at uniform speed in warm weather, and under favorable conditions. Cold weather and high winds will both operate to increase the resistance above the amounts shown.

JOINT COMMITTEE OF TECHNICAL SOCIETIES, VANCOUVER BRANCH.

On the recommendation of the Joint Technical Committee of British Columbia appointed provisionally a couple of weeks ago, that body is to be recognized as a permanent committee. It will be known as the British Columbia Joint Committee of Technical Societies.

The committee was formed a couple of weeks ago, when representatives were appointed by the Canadian Mining Institute, the Vancouver Chamber of Mines, the Canadian Society of Civil Engineers, the British Columbia Architectural Society, the Chemical Society, the British Columbia University, the University Club and the Society of Electrical Engineers. Mr. R. F. Hayward, general manager and chief engineer of the Western Canada Power Co., was appointed as chairman.

The Mechanical Engineering Company, Montreal, are moving their business to Three Rivers, Que. The new factory will be of brick construction with concrete floors and columns. The plant will be modern in every way and cost approximately $100,000. A large machine shop will be the most important feature of the plant, where new machinery will be installed Mr. Barrie is the superintendent.

DUST PREVENTATIVES AND BITUMINOUS BINDERS.*

By G. Cameron Parker, M.A.Sc., A.M.Can.Soc.C.E.

IT is not the purpose in this paper to discuss nor promote discussion on the technical points connected with the selection and use of dust preventatives and bituminous binders but to approach the subject from the standpoint of the road builder, a person whose time is too fully occupied with other matters to permit any attention to the complicated problems involved in the production, or chemistry of these materials.

The presence of dust on a stone or gravel road is an indication of wear, and while to the property owners along the road it is a decided nuisance, to the road builder it represents dollars and cents that have been paid for crushed stone or gravel. The application, therefore, of some medium which will prevent the removal of the powdered stone in the form of dust results not only in the elimination of the dust nuisance but in the prolongation of the life of the road.

Two general methods may be followed: the frequent application of light, inexpensive materials, the effectiveness of which is only shortlived; or treatment with a heavy material containing a non-volatile base or residue which remains on the surface of the road or is incorporated in the wearing course.

For the purpose of discussion we will consider the materials under the four general headings: dust palliatives, protective mediums, carpeting mediums, and binders.

Palliatives.—Palliatives, as the name implies, are primarily for the purpose of retaining the dust on the road surface, rather than for the prevention of its formation. They should be quite a fluid in order that they can be applied without heating and that they may spread over the surface in a thin, even layer and hold the particles of dust together without impregnating the surface of the road. It is not necessary that they possess binding qualities nor that when applied this property be developed. We need not consider water, salt solutions, granular salts, emulsions, nor non-asphaltic oils. Frequent applications are required for effectiveness and for this reason their use is confined to part and suburban roads, their place being taken on rural highways by materials of which not more than one application per season is necessary. Asphaltic oils, when containing more than 20 or 25 per cent. of asphalt, cease to come under the category of dust preventatives and take on the nature of protective coatings.

Protective Coatings.—When a road is required to serve a small proportion of motor traffic it is necessary to use a material which not only retains the dust but forms a protective film over the road surface, and which resists the combined action of horse-drawn and motor traffic to a greater degree than ordinary palliatives.

Protective coating materials should be fluid at ordinary temperatures in order that they may be applied cold and that they may spread uniformly. They should contain a small amount of volatile oils which evaporate, leaving a cementitious film on the surface. A large percentage of volatile matter is objectionable, particularly if in evaporating it leaves a residue which becomes hard or brittle on exposure.

*Paper read before the 3rd Annual Conference on Road Construction, Toronto, March 27-30, 1917.

Light refined tars which are fluid at ordinary temperatures and are easily applied, as well as asphaltic oils containing from 40 to 55 per cent. of asphalt, have given satisfaction in this class of work. The amount applied should rarely exceed 1/5 of an Imperial gallon per square yard and excessive amounts are to be strictly avoided.

Carpeting Mediums.—When the proportion of motor traffic is so great that the protective coating is destroyed, a thin mat or carpet of bituminous material has been found effective. The tendency for the horses' shoes and the steel tires to cut up the surface is overcome by the ironing action of the rubber tires of the motor vehicles.

Carpeting mediums are applied hot, being immediately followed with a coating of stone screenings, pea gravel or coarse sand. When properly applied the result obtained should be a thin mat or carpet on the surface of the road consisting of the bituminous material and the mineral matter. At ordinary temperatures carpeting mediums should be viscous but not fluid, in order that they will spread in a comparatively thin layer and not chill and solidify in a thick mat, on striking the cold surface of the road. They may or may not contain a small percentage of volatile matter but this will depend on the nature of the material used. Shortly after application they should develop a degree of cementitiousness

From Tank Car to Pressure Distributor.

forming a strong bond between the road surface and the mineral coating.

Asphaltic oils containing from 60 to 80 per cent. of asphalt, and refined tars containing few or no constituents distilling at a temperature lower than 170° C. are effective as carpeting mediums. Although the amount of material to be applied will vary according to the condition of the surface to be treated and the nature of the material used, for the purposes of comparison from 1/3 to 1/2 of an Imperial gallon per square yard may be considered an average application.

Where the proportion of motor traffic is so great that protective and carpet coatings are ineffective it becomes necessary to incorporate the bituminous materials in the wearing surface. Two methods are used: in one the road is built as in the case of waterbound macadam construction and prior to the application of the screenings the bituminous cement is applied to the surface either by pouring or under pressure, filling the voids in the top course of the road. This is known as the penetration method. In the mixing method the stone forming the top course of the road is mixed with the bituminous cement, spread on the foundation and rolled. This method of construction, however, is beyond the scope of this paper

and is only mentioned in passing. The penetration method, on account of the small outlay necessary for plant, is particularly adapted to use on rural highways.

Penetration materials are solid at ordinary temperatures and consequently must be heated before they can be manipulated. As previously stated, they are applied by gravity from pouring cans or tanks or under pressure from specially constructed distributors. As in the case of all materials which require heating, they should, consequently, be of such a nature that they will not ignite at the temperature to which they must be heated in order to render them fluid, nor should they undergo any change in characteristics due to such heating. On cooling in the road surface they should return to their original state, forming a strong bond in the surface of the road. The point of greatest importance in the selection of material for this work is the choice of one having the proper consistency when cold. This property should be specified with due consideration of the size of the stone, the proportions of the various sizes present and the character of the traffic which will be carried by the road.

Heavy asphaltic oils, oil and fluxed native asphalts and heavy refined tars are used in the penetration method, the grade used being governed by the conditions mentioned above.

For repair of bituminous surfaces there has recently been developed asphalt and tar emulsions. They consist of the ordinary bituminous material with the addition of a small amount of alkali which renders the material miscible with water. When received from the manufacturer the material is thick and contains only a small amount of water and is mixed with an excess of water on the road and added to the loose stone. The mixture is then tamped into holes and depressions and in a short time hardens, taking on the same characteristics as the surface of the road. The transforming of the bituminous material into an emulsion renders possible the patching of the road with a material corresponding in consistency to the material that was used on the construction of the road without preheating. They should not, however, be used without a thorough investigation as to their effectiveness.

A discussion on bituminous materials would be incomplete without mention of the formulating and use of specifications upder which the materials are to be supplied. As in the purchase of other manufactured materials, the use of specifications is to be strongly recommended and is to be urged for the same reasons as those which have caused the universal use of specifications in the purchase of cement, steel, and other materials of construction. The first and most important word of warning in connection with specifications for bituminous road materials is that against the attempt to formulate a specification from a number of others, picking out some clauses from this one and some from that. The properties of the materials are closely interrelated and the adoption of one clause from one specification may render those from another impossible of fulfilment. In the second place, do not assume that all specifications will cover the materials that are wanted for any particular class of work. The virtue of a specification lies in the results that are obtained from the use of materials purchased thereunder. Investigation should, therefore, be started from this point, and when successful results have been found one can be reasonably sure that, conditions being the same, the specifications under which the materials that gave the satisfactory results were purchased, are safe to use.

SHRINKAGE IN FILLS.

The following table on shrinkage in fills is taken from the February bulletin of the American Railway Engineering Association. The association has been considering this question and in order to get what was the usual practice in this connection the following question was sent to railway officials and railway contractors: What allowance for shrinkage, both in width and height, have you found satisfactory for different heights of fill and different materials: first, on new location, and second, under traffic? The accompanying table is a summary of some of the replies sent in:—

Shrinkage in Fills.

Atlantic Coast Line—10% for sand-clay soils.

Chicago & Alton—15% for clay or loam deposits from trestles.

Chicago, Rock Island & Pacific—10% on new and old work.

Illinois Central—10% on new location.

Illinois Central—3% in height and 10% in width under traffic.

New York, New Haven & Hartford—10% on new location.

New York, New Haven & Hartford—3% under traffic.

Seaboard Air Line—10% for height; fills 15% wider than standard.

Rock Island Lines—About 10% is general rule.

Grand Trunk—1 in 10 for ordinary earth fill.

Grand Trunk—1 in 20 in sand or gravel.

Soo Line—Embankment with cars from trestle, ½ to 1% per foot of elevation.

David W. Flickwir*—2 ft. for each 10 ft. in height.

John F. Dolan*—10% for shrinkage.

P. McManus*—On new location: Earth, up to 15 ft., 10%; up to 30 ft., 12½%; up to 50 ft., 15%.

Paterson-Moran Co.*—7 to 10% in clay.

C. W. Lane & Co.*—10% for width or height.

C. P. Bower*—Earth, about 1½ ft. higher for 25-ft. fill.

*Railway contractor.

The conclusions of the committee were as follow: In determining the allowance for shrinkage to be made in a fill, it should be remembered primarily that it is easier to add to the height of a fill that settles than to lower the track if the settlement does not amount to as much as that anticipated in the original allowance. Therefore, unless the shrinkage of a material is well-known in the conditions under which the fill is made, it is best to be well on the safe side; *i.e.*, little or no allowance should be made in height; the extra material, when possible, being deposited where it will be conveniently available for raising the track, as required. The allowance in width should be from about 5 per cent. to 20 per cent. of the height of the fill, depending on the material and conditions.

The material used for fill varies in shrinkage from sound, non-disintegrating rock, or gravel, which is least, to certain swelling clays, which give the greatest shrinkage both in compactibility and erosion at the slopes. While vegetable loam has a large percentage of actual shrinkage, it so quickly produces a protection cover of vegetation that the shrinkage due to erosion is usually small. Where frozen material must be used in making a fill, heavy settlement must be expected, and this is to be avoided where possible.

VENTILATION OF THE CONNAUGHT TUNNEL.*

By J. G. Sullivan, C.E.
Chief Engineer, Western Lines, Canadian Pacific Railway.

WHEN the Connaught tunnel was first planned, it was generally supposed that it would be necessary to operate by electricity, but upon further studies of this subject it was found that the large cost of installing a plant for this short section and the enormous extra expense of operation would have entirely wiped out any economical saving made by the construction of the tunnel. Therefore, a study was at once commenced on other methods of operation.

As a result of the study a plan was adopted of blowing air through the tunnel by the use of fans, similar to the method adopted by an Italian engineer in the ventilation of the St. Gothard tunnel a number of years ago. However, instead of putting up an obstruction at the portal of the tunnel where the fans are situated, to prevent the air from coming out of that end, a nozzle patented by Chas. S. Churchill and the late C. C. Wentworth was adopted, plans of which are illustrated in drawings Figs. 1, 2 and 3. With this system we can with perfect safety operate this tunnel with steam locomotives.

The principle of this nozzle is as follows: Air is forced into a comparatively large chamber which terminates in a nozzle inside the tunnel. If the pressure is great enough, there is sufficient energy in the air leaving the nozzle at high velocities to overcome the resistance offered by friction, variation in barometric pressure or other resistance to the flow of air that may occur in the tunnel. In general, where tunnels are comparatively short, this ventilating plant would be located at the lower end of the tunnel, and trains reduced to a speed lower than the velocity of air in the tunnel, in this way the smoke and gases being blown ahead of the moving train. In a tunnel as long as the Connaught tunnel, this method of operation with a fan system was entirely out of the question, but as the tunnel is of a large area, it was decided to establish the ventilating plant at the higher end of the tunnel and blow fresh air against the approaching trains on the up-grade, and thus dilute the gases coming from the locomotive. The dangerous gas generated by a

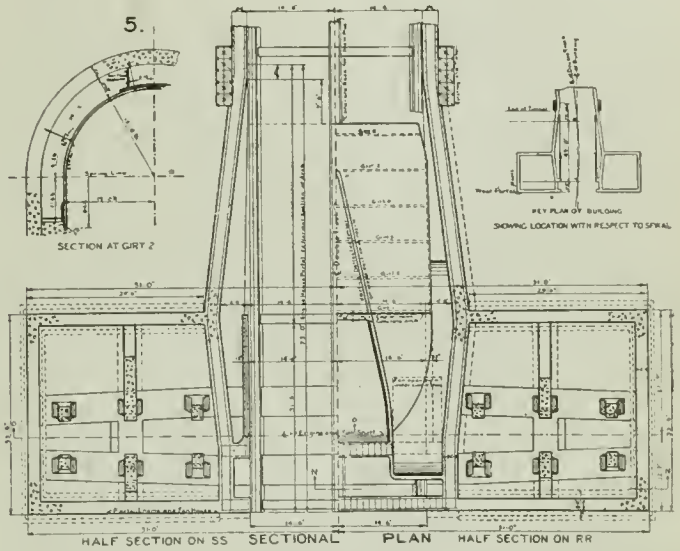


Fig. 1.

locomotive is carbon monoxide, and this gas is usually generated in cases of an accident where the draught to a heavy coal fire is shut off. The ordinary carbon dioxide, the usual resultant of complete combustion, is not so dangerous and a much larger percentage of the latter gas in air is permissible. As our locomotives on this section use oil for fuel, in case of a sudden stop the fire can be shut off and there is no danger of producing the deadly carbon monoxide.

Returning again to the plans of the ventilating system, the usual method is to put the fans at the side of

*Cornell Civil Engineer, February.

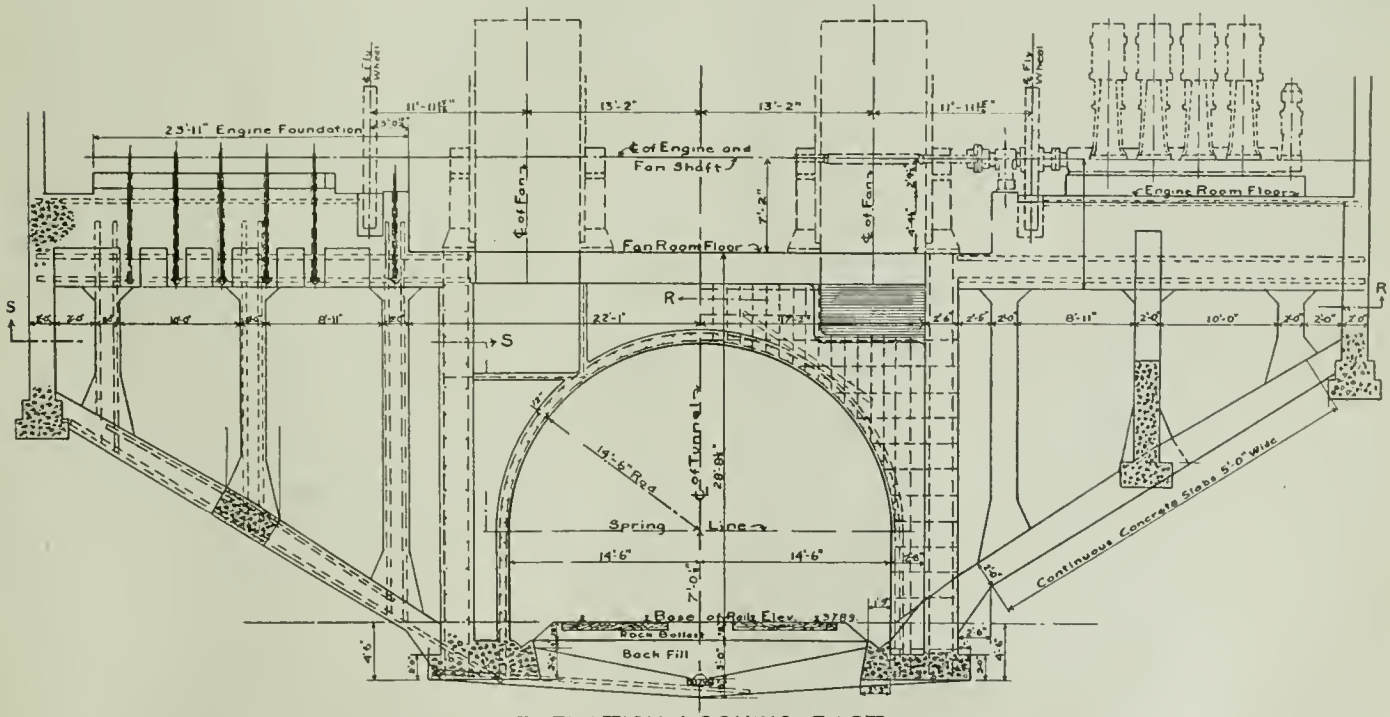


Fig. 2.

the track a little above the elevation of the base of rail. In this case, however, since the portal of the tunnel is in a very deep cut, it was decided to put the fans over the portal. Instead of running these fans by engines driven by steam, it was further decided to use Diesel engines. These engines will only consume 0.4 to 0.5 pounds oil per horse-power hour of work, while the best we could hope to get from a boiler would be one horse-power for every 2 or 2.5 pounds oil, and possibly not as good results in this case where the work is only intermittent, the fans being run only at intervals when a train is on the up-grade through the tunnel, and for a sufficient length of time after the train passes to entirely clear the tunnel of gas.

In Fig. 1 is a small diagram showing the location of the plant in reference to the spiral of a 4 degree curve at the entrance of the tunnel. The reason I show it here is to give a general outline of air space and nozzle, and I might state here, that this air space was greatly reduced from the original plans on the suggestion of the engineers

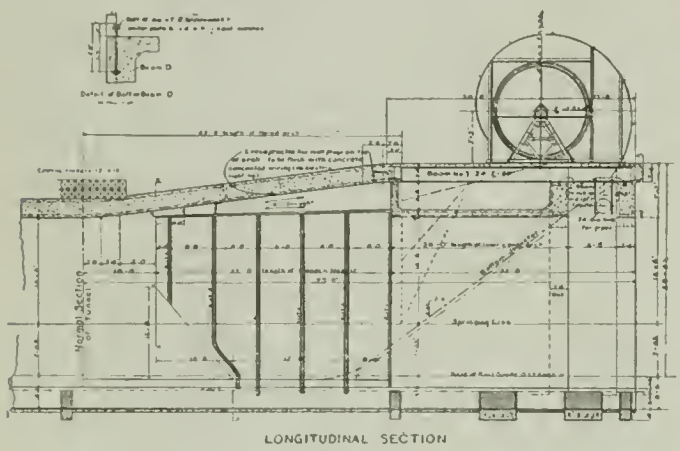


Fig. 3.

of the company supplying the fans; the idea being, that there was nothing to be gained by changing from dynamic pressure as the air left the fans, to a static pressure in a large chamber and then again change to dynamic pressure in the air leaving the nozzle at a high velocity. All that was required was a chamber large enough to allow the air to spread out to the flat long nozzle on the circumference of the tunnel. The fan house between the two engine rooms is being left entirely open, thereby offering as little resistance as possible to the flow of air from the outside to the fans.

Fig. 1 is a general plan and on the right-hand side shows a deflector keeping the air from each fan separated to a point within seven or eight feet of the opening of the nozzle. The reason for introducing this feature is that in the operation of Diesel engines, they run at a constant speed and will practically carry no great overload. When it is necessary to shut down one engine and run only one fan, if the air was allowed to spread over the entire nozzle, the resistance would be reduced, the fan would throw somewhat more air and paradoxical as this may seem, would require more horse-power to drive the fan, which would necessitate installing dampers to choke the output of the fan and also to entirely shut off the opening of the idle second fan to prevent the air coming back through it. The Diesel engines are of Swedish pattern, manufactured by the McIntosh & Seymour Corporation, Auburn, N.Y., and each engine consists of 4 cylinders, 4-cycle type and is of 500 rated horse-power at sea level. The elevations and sections with the arrangements of engines are shown in Fig. 2.

A change was made in the original plans by building the inside arch from the portal proper as far back as the engine house extended, of concrete, and in this way eliminating entirely a great number of rods that were in the air chamber holding the wooden arch in place.

Another innovation was the use of rails as arch ribs for the nozzle lining. This only required one stay to be put through the air space for each rib instead of having stays every three or four feet which would offer obstruction to the free passage of the air. These features are shown in Figs. 1, 2 and 3. The bottom of the nozzle is cut away to enlarge the opening of the nozzle at grade line which is a development of the opening of the nozzle to keep the centre of gravity of the moving air approximately at the centre of the section of the tunnel.

The installation of this ventilating plant is not yet entirely complete. The tunnel was opened for operation December 9th, 1916, when one fan was installed and which has been capable of properly ventilating the tunnel up to the present time. No annoyance or trouble of any kind from gases or smoke has been experienced in this tunnel.

The work was laid out and commenced under Mr. F. F. Busteed, M.Can.Soc.C.E., engineer in charge of double tracking. It has recently been under the supervision of Mr. W. A. James, M.Can.Soc.C.E., engineer of construction, Western Lines, with Mr. H. G. Barber as assistant engineer, Mr. T. Martin, resident engineer at the west and Mr. J. R. C. Macredie, M.Can.Soc.C.E., resident engineer at the east end. The contractors are Messrs. Foley Bros., Welch & Stewart. The construction work was supervised for the contractors by Mr. A. C. Dennis, M.Can.Soc.C.E.

SASKATCHEWAN BRANCH, JOINT COMMITTEE OF TECHNICAL ORGANIZATIONS.

Following the example set in the province of Ontario, a Joint Committee of Technical Organizations, Saskatchewan Branch, was formed with the seat at Regina, in which the Regina Branch of the Canadian Society of Civil Engineers, the Provincial Association of Architects, the Society of Saskatchewan Land Surveyors, the Saskatoon Engineering Society and the Canadian Engineers (3rd field troop) are represented by two members each. Mr. L. A. Thornton, Mem.Can.Soc.C.E., was elected honorary chairman, and Mr. J. N. de Stein, Mem.Can.Soc.C.E., honorary secretary. The committee has started at once to go into the work of devising means by which the experience of engineers in the province could best be utilized to assist the Honorary Advisory Council for Scientific and Industrial Research at Ottawa and the National Service Board. A complete census of all technically trained men in the province will be undertaken at once by means of cards, which cards when filled out will give in detail everyone's special qualifications. An inventory of natural and industrial resources is also contemplated, though the details of this survey have not yet been completed. Assistance in the vocational training of returned soldiers, advice and help in recruiting for the Canadian Engineers, the working out of a tentative mobilization plan for home defence in connection with this latter body, etc., are some of the lines along which this committee is working.

The early formation of a Dominion Committee of Technical Organizations has also been suggested to the Ontario Branch.

CULVERTS.*

By Arthur Sedgwick,
Department of Public Highways, Ontario.

A CULVERT, being much smaller and simpler than even an ordinary bridge, its cost will be proportionately less, but the number of culverts required per mile of road makes the total cost thereof as high or higher than the cost of our bridges. To reduce the cost and improve the methods of construction requires the constant, careful attention of the municipal official responsible for their construction and maintenance.

I believe it is customary for the county and municipal officials to go over the roads in the spring of each year, to examine the bridges and larger culverts and order the immediate reconstruction of such of them as they find in an unsafe condition. This procedure is almost imperative since a collapse of one of these structures would probably entail very serious consequences.

It would be better if the same practice were adopted for the smaller culverts, but unfortunately these are generally left untouched in each case until somebody reports that they have been washed out or the top has broken in. When this occurs it is, of course, necessary that a new culvert be built immediately. Since it is important that the road be not blocked any longer than is absolutely necessary, it frequently happens that the culvert is hastily built without regard to cost or for what is required to make a durable and satisfactory job.

It must be conceded that the expected additional life of such of our old wooden culverts still existent cannot be appreciable and therefore little or nothing is gained by allowing them to remain until actual failure takes place. Besides, there is always the risk of accidents to be considered.

Where these precautions are not taken, and the culverts are left until failure takes place, there is a natural temptation to save time by putting in a large pipe where the size of opening and natural conditions would otherwise suggest a concrete box type of construction being used.

Concrete or vitrified clay pipe should not be used for culverts where there is a danger of water standing in them and freezing. Neither should they be used unless an earth fill at least two feet in thickness can be provided over them. Otherwise they will become cracked with the frost and ice and become displaced by the weight and impact of the traffic on the road. Corrugated iron pipe, especially the larger sizes, should also have plenty of fill over them, or they will bend and become distorted under the loads passing over them.

The chief precaution to be taken in using any kind of pipe culvert is to thoroughly compact the earth around it, especially around the lower half. To this end the trench should be dug wide enough to permit an iron ram to be used to compact the filling underneath. If this is not done the pipe may break or bend from the pressure above, or the water may find its way underneath and by freezing, force the pipe out of position or may eventually cause a "washout."

To prevent the water from undermining the ends of the culvert and working a passage through on the outside, end walls, preferably built of concrete, should be provided; or, where corrugated iron pipe is used, end walls of the same material may be used. It should be remembered, though, that these iron culverts cannot be expected to last indefinitely.

Pipes over three feet in diameter should preferably not be used. They are clumsy to handle and are apt to crack or bend sooner or later, no matter what precautions are taken. Square box masonry culverts will give better satisfaction, even though the first cost be greater.

Where one is sure the ditch or watercourse will not require deepening, such box culverts, where they are not over five feet square, can be built with a reinforced concrete floor and a considerable saving of material result. Otherwise, the sides must be carried down to footings reaching below the frost line. The floor sides and top can be built of concrete about one foot thick and reinforced. For such sizes of culverts, wire mesh or expanded metal make a convenient form of reinforcement. Such a type of culvert will give permanent results at a very reasonable cost.

Square-built culverts give a larger waterway than a circular one of the same width. With a circular section, the water has to rise to some height before there is any appreciable volume of discharge. This is an important factor in flat drainage areas where it is most desirable to keep the level of the water in the drains as low as possible. Again, during abnormal flood conditions the natural watercourses expand in width and thus provide for themselves an unusually large area of waterway. A circular culvert reduces in width very rapidly above the centre line. It will be seen, therefore, that under such flood conditions there is a tendency for such a culvert to restrict the flow of water and cause it to rise still higher.

Culverts less than fifteen inches in diameter should not be used as they are apt to become blocked with sediment, ice, or coarse debris from the road-side.

Moderate-sized culverts are not readily discernable to motor vehicle drivers, and they should therefore be built the full width of the road grade. The required safety thus ensured is well worth the moderate additional cost entailed.

Culverts that are not built the full width of road-grade should be provided with strong guard-rails of such size and type that they may be readily seen by the travelling public under unfavorable conditions. The guard-rail is the only warning a stranger using the road has of his approach to the culvert. The use of gas pipe for railings should be discouraged as much as possible, as it is difficult to see them, especially at night. Concrete spindle railings are strong, easily seen and when carefully built present a very attractive appearance. They must, of course, have well-bonded and reinforced posts, top railing and curbs.

Municipalities which have not the necessary experience and facilities for constructing the above type, may use a solid reinforced concrete railing as they may advantageously use reinforced concrete posts with three or more iron pipe rails built into them.

In conclusion, let me urge the desirability of putting a better finish on our bridges and culverts than has been the prevailing custom in too many of our local municipalities in the past. These structures which in most cases are expected to last indefinitely, should have the appearance and substantiality which will conform to that of the magnificent system of roads which we may expect to have in the not distant future.

*Paper read before the 3rd Annual Conference on Road Construction, Toronto, March 27th to 30th, 1917.

CANADIAN WOODS FOR STRUCTURAL TIMBERS*

CANADA'S present supply of commercial timber has been estimated at from 500 to 800 billion feet, board measure, covering an area of approximately 250,000,000 acres. This estimate, which is about one-half the forested area of the Dominion, refers only to saw-timber; material suitable for pulpwood, firewood, poles, etc., not being included. Russia is believed to have the largest timber resources of any country in the world; the United States is second, and Canada is third on the list.

Principal Structural Woods.—The heavy structural species of Canada named in order of merit and resources are: Douglas fir, western hemlock, eastern hemlock, western yellow pine, western larch, red pine, and eastern larch.

It is a general rule that the heavier a wood is the stronger and harder it will be. This is not only the case in comparing one species with another but also where timbers of the same species are examined. The effect of knots and other defects is taken up in detail in the section on grading, but some of the more general results may be stated here.

The density or absolutely dry weight of wood is usually a direct measure of its strength. Wood with a considerable development of summer-wood is generally heavier and stronger than wood with a smaller proportion of summer-wood.

Checks and shakes in beams reduce the area which resists horizontal shear and are most harmful when they are in the centre half of the height of the beam.

Very rapid or very slow growth in conifers usually produces a wood lacking in density and of inferior strength.

The strength of posts or columns containing knots decreases as the knots increase in size.

Sound knots do not weaken wood subjected to compression perpendicular to the grain.

Large specimens tested in compression perpendicular to the grain show but little increase in strength due to seasoning.

If structural timbers are seasoned slowly, in order to avoid checking, there should be an increase in strength, but it is not safe to base working stresses on results secured from any but green material.

Discussion of the Most Important Coniferous Woods of Canada.—In 1913 there was more Douglas fir timber cut in Canada than any other single species. Only the spruces, collectively, produced more timber than did Douglas fir, while in 1914 the spruces and white pines both produced more. Although in 1915 the cut of Douglas fir decreased, it may be expected to increase rapidly hereafter in yearly production, as it is the only timber in North America of which great areas, accessible to easy development, remain untouched. British Columbia cut practically all of the 601,643,000 feet, board measure, of Douglas fir, worth $6,810,000 at an average value of $11.32 per thousand feet, which were cut in 1914. In 1915 the production was 453,534,000 feet, board measure, with an average value of $11.76 per thousand.

Douglas fir is at present one of the most important of Canadian woods, and within a few years it will probably be the most widely used and valued of Canadian timbers. It is the largest structural timber growing in Canada or the United States. In Canada it is found in British Columbia and to a limited extent in Alberta. Trees have been measured up to 380 feet high with a maximum diameter of 15 feet, the largest trees scale as high as 60,000 feet, board measure. This great size places the timber in the highest class for large timbers free from defects.

So far as structural timber in the Dominion is concerned, Douglas fir is by all means the most important, although there are several other species which produce very good structural timber. According to recent estimates of the Commission of Conservation, the total supply of merchantable Douglas fir timber is about 75 billion feet, board measure, and since the tree grows satisfactorily under reforestation there is little reason to believe the supply will be exhausted for many years. In fact, proper protection should insure a perpetual supply.

Douglas fir is manufactured into almost all forms known to the saw-mill operator and a very large amount of the wood is also utilized in the form of round or hewn timber. For bridge, trestle, and harbor work Douglas fir is superior in many ways to any other Canadian timber. It is largely used by the railways in the form of ties, piling, car, and bridge material. It has long been the most important timber for boats and ships on the Pacific Coast, being suitable for both outside and inside work, especially for decking, planking, keels, yards, ribs, and finish. Increasing amounts of Douglas fir are being used in furniture making and in this line it is particularly adapted to "mission" furniture. Tight and slack cooperage, tanks of all kinds, conduits and water pipes, paving blocks, boxes, and pulpwood may be mentioned as further illustrations of its utilization.

Although the properties of Douglas fir enable it to be employed in such a variety of ways, it is probably most widely known as a structural material. For this purpose it is inferior to no other wood, and its straight, clear trunks can supply timbers of the largest size and highest quality. Pieces 2 feet by 2 feet in section and 100 or more feet long can readily be supplied by mills in British Columbia equipped to handle such lengths. It may be said, then, that Douglas fir is not only of first value as a timber for all kinds of structural work but is also suitable for a greater variety of uses in the manufacture of various products than any other Canadian wood, with the possible exception of white pine.

Southern (Longleaf) Pine.—Undoubtedly the two most important American structural timbers at the present time are Douglas fir and the southern pines. It may be of interest in this connection to draw attention to certain characteristics of the two timbers as brought out by parallel tests made by the United States Forest Service and by the Forest Products Laboratories of Canada.

As far as the designing engineer is concerned and apart from considerations of durability, etc., the properties of a timber which may affect the design of a structure of this material are as follows:—

1. Timber beams: (*a*) Strength in bending; (*b*) strength in longitudinal shear; (*c*) stiffness.
2. Timber columns: Strength in compression parallel to grain.
3. Bearing areas of timber beams and sills: Strength in compression perpendicular to grain.
4. All members: Dead weight of material.

The accompanying table (Table I.) has been calculated from the sources indicated (largely United States Forest Service tests) to show the comparative properties of Douglas fir and longleaf pine in respect to the various

*Abstracted from "Canadian Woods for Structural Timbers," published by the Forestry Branch, Department of the Interior.

factors mentioned above. In all cases the strength values of Douglas fir have been expressed as percentages of the corresponding values given for longleaf pine. In cases where the strength of Douglas fir exceeds that of longleaf pine the figures are shown in bold-face type; in cases where the reverse is true the figures are shown in ordinary type. By noting the grouping of the bold-face and ordinary type the comparative strength of the two species can be readily seen.

Taking up in order the factors mentioned above as affecting the design of timber structures reference to Table 1. leads to the following conclusions:—

1. Strength in Bending.—In modulus of rupture the majority of tests show Douglas fir to be weaker than long-leaf pine by about 10 per cent. On the other hand, all tests with the exception of two show Douglas fir to be stronger than longleaf pine by varying amounts, say, 10 per cent. on the average, in fibre stress at elastic limit.

Table I.—Comparative Properties of Douglas Fir and Longleaf Pine. Values for Douglas Fir as Percentages of Corresponding Values for Longleaf Pine.

Class of Specimen.	Static Bending.			Compression Parallel to grain.		Compression Perpendicular to grain C. S. at E. L.	Longitudinal Shearing Strength.	Weight.
	F. S. at E. L.	M. of R.	M. of E.	C. S. at E. L.	C. S. at M. L.			
Small specimens	**105·7**	**91·3**	**103·7**		91·6		78·6	
"	99·1	90 1	97·4				83 5	
"	**110·0**	**92·3**	**103·9**				79·4	
"	**105·5**	91 3	**103·7**		91·6			
"	**102·4**	**94·9**	**104·5**	**100·2**	93·7	**109 0**	89 9	83·9
"	**102·7**	95·9	96·1		94·2		76 0	87·1
Structural timber	**106·3**	97·5	**103·7**	79·6	72·8	**100·3**		80·0
"	**123·8**	**110·7**	90·8	94·1	88·7	**111·6**		71·8
"	**105·2**	83·4	96·8	80·0	72·9	**100·0**		80·6
"	**126·0**	**109·8**	**111·0**					
"	**117·9**	**112·6**	**112·3**					
All sizes—Average	98·0	87·4	**111·4**					

Tests of long duration on timber have shown that if a beam is loaded in excess of its elastic limit it will eventually fail. In accordance with this it appears that the elastic limit stress is the greatest stress which can be safely used in timber structures, and it would therefore be logical to base working stresses for design on the elastic limit stress and *not* on the ultimate breaking strength as determined in the testing machine. This practice is at present followed in determining suitable standard working stresses for other structural materials such as steel, and it is now being recognized that the elastic limit is the logical basis for design in the case of timber as well.

Douglas fir should, therefore, be capable of taking a greater working stress in bending than longleaf pine by the amount mentioned, for the same degree of safety. This, however, would not apply in the case of extremely short beams.

2. Strength in Longitudinal Shear.—All tests show Douglas fir to be weaker than longleaf pine by from 20 to 25 per cent. In the case of beams so short that strength in shear rather than bending strength becomes the deciding factor, longleaf pine should accordingly be allowed a working stress greater by the amount mentioned.

3. Stiffness.—Not infrequently, as in the case of ceiling joists under certain conditions, the maximum deflection of a beam becomes the deciding factor in its design rather than its strength. A stiff timber of high modulus of elasticity would in this case be desirable. Referring to the table it will be seen that in the majority of cases Douglas fir is credited with a higher modulus of elasticity than longleaf pine by from 4 to 10 per cent., although there are a few exceptions to this rule. It would look as though the safe working modulus of elasticity for Douglas fir might be taken to be about 5 per cent. greater than that for longleaf pine. In any case the same modulus could certainly be used.

4. Strength in Compression parallel to grain.—All tests, almost without exception in the case of stress at elastic limit and without any exception in the case of maximum crushing strength, show Douglas fir to be from 10 to 20 per cent. weaker than longleaf pine. A greater working stress for longleaf pine than for Douglas fir in the case of columns would, in accordance with this, be good practice.

5. Strength in Compression Perpendicular to Grain.—All tests without exception show Douglas fir to have somewhat greater strength in compression perpendicular to grain than longleaf pine, by amounts ranging up to 10 per cent., indicating that greater working stresses for Douglas fir in compression perpendicular to grain would be permissible.

6. Weight of Material.—All the tests show Douglas fir to be lighter than longleaf pine by about 20 per cent. on the average. The obvious advantages of a structural material of light weight over one of heavier weight, both having the same strength, are two-fold: (1) Less dead weight to be supported in the structure, leaving greater net strength effective for supporting live loading; (2) less weight to be handled.

In the present instance the former consideration is of little importance because of the magnitude of the loads supported in proportion to the weight of the material used. The latter consideration, however, involves a very considerable difference in charges for transportation and labor of handling.

In the above comparison an effort has been made not to favor either one timber or the other, existing reliable comparative figures having been taken and analyzed without regard to their bearing on the result. It is probable that the comparison is fairly equitable, or even conservative as to the strength of Douglas fir.

A nitrogen plant is being erected at La Grande, Wash., near the Tacoma municipal power plant, from which source power was contracted for at a rate of 1.15 mills per kilowatt-hour. The power sold is surplus which the plant does not require at present, and the municipality retains the privilege of discontinuing service at any time. The American Nitrogen Products Co. is erecting the plant, which is reported to involve a $500,000 investment.

The Bureau of Navigation at Washington, D.C., reports that there were in progress or on order in United States shipyards at the beginning of the year 682 vessels of 2,098,761 tons. Of these 403, of 1,495,601 tons gross, were steel merchant vessels; 161, of 207,623 tons gross, wooden merchant vessels; and 118, of 395,537 tons displacement, war craft. The tonnage of 61 submarines which are in progress is not included.

WESTERN MINING ENGINEERS' MEETING.

The Western Branch of the Canadian Mining Institute has just concluded its twenty-fourth general meeting at Vancouver.

Among those who addressed the various sessions of the conference were R. R. Hedley, M.E., who read a paper on "The Iron and Steel Industry"; W. M. Garman, who spoke on "The Manufacture of Pig Iron"; Prof. J. G. Davidson, who spoke on "The Cottrell Process of Electrical Precipitation of Smelter Dust and Fumes."

Mr. R. R. Hedley, M.E., speaking on the iron and steel industry, said that it might be stated that there was practically no such industry in British Columbia, for the reason that the iron and steel plants are depending almost entirely for their supply on scrap iron.

It had been stated that coal is too costly to use in making coke and that there are no hematite ores available to mix with magnetite ores of the coast. It had been said that there was no market for iron or steel provided, even if it was produced here, but the speaker characterized these statements as rank pessimism. The market is naturally small now, because the product is not being turned out. The market could be easily increased and extended, however, provided the steel and iron industry was established in British Columbia to turn out the product.

Steel Needed for Shipbuilding.—The speaker contended that there is bound to be a great demand after the war for steel and iron for shipbuilding purposes. With Australia, Japan and New Zealand building steel ships, British Columbia is commencing to develop also, and Mr. Hedley expressed the opinion that there was no doubt that a profitable market could be developed in British Columbia which would absorb all the iron and steel which could be turned out. The available tonnage of ships for the first year following the war would be short, but within a year after it closes there will be plenty of vessels to handle all the material that will be demanded by countries across the Pacific. He urged British Columbia to prepare to handle this large new trade.

Coke Outlook Promising.—Mr. Hedley is optimistic as to the production of coal for coking purposes. He stated his belief that certain seams on Vancouver Island will produce a better coke for metallurgical work than any hitherto discovered. He then went into a technical dissertation on the cost per ton of producing this coke, which he places at about $6.

He stated that it was possible for the by-products of coke to be utilized at a saving of from $2 to $2.50 per ton, thus reducing the actual cost of the coke.

The speaker admitted that local labor conditions were adverse, but said that by introducing efficiency and judicious management this difficulty could be overcome.

With reference to iron ores the speaker said that the occurrence of sulphur in magnetite ores is not necessarily an evil. As a rule, coast ores are very high in iron and low in both sulphur and phosphorus. Mr. Hedley explained the nodulizing, briquetting and cintering methods of producing pig iron.

Cheap Production Possible.—Many coast ores in British Columbia carry as high as 1½ per cent. copper, which is not a detriment to the ore. He told of shipping himself from Talssoo Harbor three years ago 1,100 tons of magnetite ore which contained 62 per cent. iron, 1 8/10 per cent. copper, 3 6/10 per cent. silica, besides gold values of 40 cents per ton and 4 to 10 ounces of silver per ton. He said that similar ore can be found in large bodies in many places on the coast. As to hematite, he was pleased to state that the provincial minister of mines had stated that there is an adequate supply. Summarizing, he said that he is satisfied as to the supply of both magnetite and hematite ore, limestone of a superior quality, coal which can be converted into metallurgical coke, labor which is to be trained and fostered and a market to be found or made. As to the use of electrical furnaces as opposed to gas furnaces, he said that their installation will depend on the cheapness of power. The cheapest power known, water power, is unlimited in British Columbia. It was his opinion that it costs more to produce a ton of iron in Pittsburg than it will on the coast.

FOURTH CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.

The fourth Canadian and International Good Roads Congress will open April 10th and continue until April 14th, 1917. In addition to the interesting and educational program of addresses and lectures that has been arranged there will be a very complete display of road materials and road-building machinery. The following is the tentative program:—

"Modern Methods of Maintaining Earth, Clay and Sand Roads," Paul D. Sargent, chief engineer, State Highway Commission of Maine.

"Drainage and Foundations," Geo. Hogarth, chief engineer, Ontario Public Highways Department.

"The Highway Laws of Ontario," W. A. McLean, Deputy Minister of Highways, Ontario.

"Bituminous Roads and Pavements," Col. Wm. D. Sohier, chairman, Massachusetts Highway Commission.

"Cement Concrete Roads and Pavements," T. Harry Jones, city engineer, Brantford.

"The Construction and Maintenance of Gravel and Macadam Roads," James H. MacDonald, ex-state highway commissioner of Connecticut.

"Highway Bridges and Culverts," W. G. Yorston, assistant road commissioner, province of Nova Scotia.

"Safety on the Public Highways," R. B. Morley, general manager, Ontario Safety League.

"Brick Roads and Pavements," D. T. Black, town engineer, Welland.

"Road Oils," Arthur H. Blanchard, Professor of Highway Engineering, Columbia University, New York.

"Wood Block Pavements," A. F. Macallum, commissioner of works, Ottawa.

"Modern Road Machinery: Its Selection, Use and Care," Wimund Huber, assistant engineer, Ontario Public Highways Department.

"Road Organization," Geo. S. Henry, M.P.P., Ontario.

"Granite Block Pavements," W. H. Connell, chief of Department of Public Works, Philadelphia.

"Methods Employed for Making Road Material Surveys," L. Reinecke, Geological Survey, Department of Mines, Ottawa.

"The Highway in Relation to Land Development," Thos. Adams, town planning adviser, Commission of Conservation, Ottawa.

BEST PRACTICE IN CONCRETE ROAD CONSTRUCTION.*

By H. E. Breed,
Deputy Commissioner of Highways, New York State.

THEORETICAL tests are fine. They are necessary to tell you what you should have as a final product. You proceed on the hypothesis they offer and then you have to wait until service and climatic conditions prove how far your hypothesis conforms to reality.

Tests for concrete materials have never been given their proper consideration, with the exception of cement, which has been tested with all the finesse of the art of testing. In general, little, if anything, has been done on the sands, which have been casually accepted if they looked good, or had ever been used before in a structure that would stand up. As for the stone or gravel, all kinds and conditions of both have been used with practically no tests at all.

Our work has shown that if we are to omit any of the tests, we might better take a chance with the cement, for of the last 455,000 barrels used only 1.4% failed to conform to the test of the American Society for Testing Materials. Fifty per cent. of these failures was due to flash set and fifty per cent. to failure on the 200-mesh sieve requirement. Had all this cement been used, that rejected for sieve requirement would have given good work, and that rejected for flash set would have been aged enough by the time it was placed in the work to give good results. There has been a far greater proportion of both sand and stone rejected for this kind of work.

Engineering skill presupposes judgment, so why not inject it into our problems? After priming ourselves with theory, let us apply it to practice. Let us make field tests that will parallel laboratory experiments; let us conduct our laboratories in such a way that their value may be significant to the man in the field, and so that their results may be checked up by him. Success of work depends upon the field man; in every case his personality helps determine the results. Put him in line with your tests, practices, etc., and his interest and co-operation will show most profitably in the work. All of our men, from the engineer in charge of the road up, are instructed in all the tests and methods of inspection and they complete them on every inspection of the work. We of New York State believe that our best results may be attributed to the *esprit de corps* engendered by this method.

Field Tests.—The principal tests which can be made in the field accurately enough for all practical purposes are:—

(1) Gradation tests for sand. Our field men are furnished with sand testers which have the ¼ in., the 20 and the 50 sieves. By using these they can be assured of getting a uniform product from the bank, for they would at once detect any change for the worse in the character of the material and would reject it. Each engineer is supposed to make a daily report of the gradations. A laboratory test, however, is essential to ascertain the presence of any deleterious matter in the sand.

(2) Test for loam and silt content in sand. This can be made in the field and checked up by the laboratory results.

For the loam test, an excess of water is added to a given quantity of sand in a glass graduate, the whole is well agitated and allowed to stand until the loam and silt has settled on top, when their percentage may be measured.

(3) Test for set. This is made by mixing the sand with cement and forming a pat with thin edges. By breaking the edges after 24 to 48 hours it may be determined how the material sets.

(4) Tests for stone and gravel. Field determinations of these materials can be made only for voids. Visual inspection should, of course, detect soft material and dirty aggregates. Such inspection on the road and at the quarry should be made constantly to know that the material is running uniform and is equal in quality to the original samples.

When we realize that nature never has two deposits alike, the importance of these tests in securing good work will be readily appreciated.

Laboratory Tests.—Laboratory tests of stone are so familiar to us all that I omit discussion of them here.

For gravel, however, we found that the rattler test in general use did not give a true abrasive value. Because of the rounded structure of the rattler, the first material that was abraded off formed a protective cushion that greatly decreased the subsequent wear upon the stone. To eliminate this condition a new pot of the same size and shape as the standard pot was designed but it is slotted at intervals to prevent cushioning by allowing the worn-off material to escape. Some of the better-known gravels which have proved successful in concrete pavements are used as standards of comparison with satisfactory results. We have also had promising results in using this pot to test slag, which in the old pot used to act the same as the gravel did.

Final Test of the Concrete.—Concrete from a batch mix is made up on the road into six-inch cubes two in number from every 500 cu. yds. of material. They are cured for 21 days in moist sand and then shipped into the laboratory and tested at 26 days. The results of these tests are given to the engineers on the work and the rivalry to have the highest test value produces good results. It is expected that these cubes shall go over 3,000 pounds per square inch compression, and if they do not we look for trouble. Of 504 cubes tested in 1916 only 13¼% were below 3,000 pounds and the determination of the defects were as follows:—

	1916.	1915.
Coarse aggregate coated	61.9%	35 %
Fine aggregate containing an excess of loam or made up of excessively fine-grained sand	25.7%	43.9%
Coarse aggregate, poor quality	6.2%	8.2%
Poor manipulation in making cubes..	6.2%	16.9%

These tests also show a grand average of 3,370 pounds compression for all 1:1½:3 mix cubes stone and gravel, while the average for the stone cubes is 3,380 pounds and the average for the gravel cubes is 3,080 pounds. Thus it is demonstrated from these tests that stone concrete is 11% stronger than gravel concrete. In comparing the two, it is fair to say that all gravels with a coating that ordinary washing will not remove should be rejected; while stone that retains much of the dust of fracture is bound to make weak concrete. This is especially true of all soft limestones, and of any stone that is crushed when it is wet.

*Abstract of paper read before the American Road Builders' Association, Boston, Mass., February 8th, 1917.

[First part of paper appeared in *The Canadian Engineer*, March 8, 1917.]

Construction.—An exact subgrade is necessary to save the concrete that would be wasted in evening up inequalities in the foundation. The extra time and attention spent on getting an exact subgrade will be well repaid.

The materials should be placed well in advance of the laying, so that when the mixer has once commenced operations the work may be continuous. If the road is being constructed of imported materials, the use of a stock pile to prevent shortage will materially reduce the loss from delays in operation. In order that the minimum amount of work may be done in taking materials from the subgrade and placing them in the mixer, it is advisable that the superintendent and foreman should each have a list of the amounts to be distributed for every hundred feet. A little attention to this detail will save largely in the item of labor.

Rejection of Materials.—Materials should be rejected before they are unloaded to come on the work. As good quality is essential in both sand and stone, both these materials should be checked up from day to day in order to secure the best results.

Equipment.—Attention should be given to the screed or strike board or template as it is often called. This should be heavy enough to screed the concrete properly, and it should be cut to conform to the crown of the road. It should be provided with handles and be shod with a steel angle-iron bent to the shape of the roadway. Wooden floats should be provided for doing the necessary floating, and the float to be used at a joint should be split in such a manner that it will ride over the joint smoothly and will cover an area of at least one foot on either side of the joint. Steel forms, while more costly than those of wood, are far more economical in the long run and pay for themselves in a short time.

Measuring Barrows.—Barrows should be of such a type that their measurement can be regulated by the bolting of boards across the rear part of the barrows to make the quantities adjustable. Forks should be provided for taking the stone from the subgrade in order to eliminate the dirt.

To insure a sufficient supply of water a pipe line should be installed, for although tank supply may amply provide for the mixer, it can scarcely take care of that and attend to sprinkling too.

The concrete road presents a good problem for the application of labor-saving devices in the handling of materials and many different installations have shown reasonable cost reductions. The industrial railroad has played a large part in this.

The forms should be placed in such a way as to give them stability and they should above all be tight. The sub-grade should be kept drenched with water immediately ahead of the laying of the concrete.

An ordinary concrete force in operation on a 16-foot road is comprised of from 32 to 35 men doing all branches of the work and it is quite often necessary to rearrange the gang so that the best results may be secured in keeping the mixer in continuous operation.

Suitable measuring tanks should be provided so that the amount of water may be such as to make the separate batches of the same consistency, the ideal consistency of concrete being where it will just settle and will not run. This is very important as the density of the resultant concrete is dependent upon it; if too wet the materials will run on the grades.

The concrete should be well spaded and kept high above the screed or strike board on the mixer side. Tamping should not be allowed. In screeding, the screed should be slowly pulled back and forth, advancing it slowly with each operation. When approaching a joint the screed should be brought up to the joint and carried back in order that the surface may be uniform. No more floating than is absolutely necessary should be resorted to as the primary object is to have the wear on the surface taken by the stone, and not by the thin mortar layer produced by floating.

Placing of joints should always be perpendicular to the surface of the pavement. If they are not, in subsequent expansion there is often riding of the slabs. In many instances it may be necessary to stiffen up the consistency of the concrete in order that the screeding on grades will not give a ridgy effect. If possible, all work on grades of over 4 per cent. should be worked up-hill. The cement factor should be taken daily and reported to the division engineer.

Curing.—Curing properly is as necessary as good construction, for upon this depends to a large extent the strength of the resultant concrete. Sprinkling should be commenced as soon as the surface will not pit and a cover of 2 inches, at least, of sand or loam should be spread over the surface. This cover should be kept saturated with water for ten days. Care should be taken, however, not to place cover until the concrete is sufficiently firm to withstand the impact caused by placing. Sprinkling should be done in such a manner as not to wash the cover from the surface. When the temperature gets below 50° F. in the middle of the day, sprinkling and cover may be omitted. When concrete is laid in cold weather its curing period should be lengthened, as low temperature retards its gain in strength. Work done in November should be allowed to cure from four to six weeks.

It has been our aim to designate essentials in design and specifications; to hold only such standards as have been proven practical, from our field and laboratory tests; and to employ only such methods of construction as will insure serviceable pavements at the lowest possible costs.

As you are aware, I have not attempted in this paper to cover the subject fully; limitation of time, to say nothing of other limitations, would not allow that. I have tried to suggest features which may some time lack sufficient attention, and to emphasize other features of whose importance we feel certain.

In conclusion, let me say that the ideas presented in this paper are based upon such knowledge as may be gained by inspection of concrete pavements in various parts of the country, and, more validly, on the actual construction in New York State of 201 miles of second-class concrete pavement, 1 : 2½ : 5 mix, a type which we have ceased using; and upon the actual construction of 364 miles of cement concrete pavement, 1 : 1½ : 3 mix, built in the last four seasons. There still remain 127 miles of this type of construction under contract in New York.

"The extension of the Chicago drainage canal for two miles at Joliet to a new 24,000 h.p. hydro-electric plant on the Des Plaines River is proposed, in order to provide power for operating pumping stations of the Chicago waterworks. The sustained opposition of the city of Joliet and of private concerns proposing water-water projects has been overcome, the city being assured of ample protection against floods and overflow. It is estimated that the extension and power plant will cost about $6,600,000 and that the work can be completed in three years. It is necessary to wait, however, for the passage of a bill by the Illinois Legislature authorizing the Sanitary District of Chicago to build the extension, dam and power plant. This bill has been prepared."—U.S. Exchange.

MAINTAINING EARTH AND CLAY ROADS.*

By A. A. Smith.

OWING to the absence in many places of rock, gravel or other hard and durable substances, with which to build good roads, and by the reason of the excessive cost of such roads, where suitable material is scarce, a large part of our public highways will of necessity remain earth and clay roads.

When one considers the number of miles of this kind of road, in any township or county in the province of Ontario and compares it with the number of miles of surfaced road, it can easily be seen that it will be many years before even one-half of them are properly surfaced with either gravel or stone. For this reason it appears most important that we should give every consideration and thought to the construction and maintenance of the common earth and clay roads.

In our effort to construct a type of road that will carry the ever-increasing motor traffic between cities, we are apt to overlook this earth road problem, where large sums of money are being spent, more often with poor results, which, if handled properly, would result in better roads and more of them, for perhaps less cost.

Before spending too much time or money on the maintenance of a road, one should bear in mind that this earth road may be the foundation for a later improved one, with a surface of gravel, stone, concrete or other hard material. It is, therefore, important to first of all be quite sure that there is no question whatever regarding the correct location.

The chief factors to bear in mind in this respect are: easy grades, proper direction, good foundation and drainage. The common error in laying out a road, is made in the endeavor to secure the shortest route between two fixed points. For this purpose the road is often made to go over hills instead of around them.

Many of our roads were originally laid out following along boundary lines of farms and concession lines, regardless of grades. Here they have been allowed to remain, where a large amount of energy and material have been wasted in trying to travel and haul loads over them and in endeavoring to improve their deplorable condition.

In locating the route, one must also bear in mind that the road for the present will be constructed out of the materials over which it passes, so it will be well to carefully study the nature of the soils and avoid, where possible, any swamps, or morasses and soils adjacent to beds of streams, not only on account of the poor nature of the road-making qualities but also on account of the difficulty of draining.

A road can never be kept hard and smooth if the water from the surrounding land drains on to it. This can often be avoided by taking a little longer route on nearby higher ground at perhaps a little greater initial cost, but certainly at a much reduced expense for maintenance.

A road should be finally located so that when constructed the length and grades will be so balanced that a minimum amount of effort will be required to go from one end to the other.

After satisfying oneself that the location of the road cannot be improved upon, the next most important feature to study is drainage. Water is, without doubt, the most destructive agent to any class of road, but much more so to an earth road, which is more susceptible to the action of water, more easily dissolved and moved by it, than any other surfaced road; for this reason, too much attention cannot be given to this problem. This is true in all climates, but more particularly in Canada, where heavy rains are prevalent during certain seasons of the year, and where the winter months are attended with severe frost and snowfalls.

Water must be kept away from the road and rain which falls on it must be made to run off as rapidly as possible.

Drainage may be divided into two sections: (1) Subdrainage; (2) surface drainage. The former will undoubtedly be required, when the road runs through wet lands, over clayey soils, or where springs exist in the soil under the road.

Various forms of underdrains are laid, some of wood and some of stone, but at the present time there is no question but that the best results are obtained by the use of tiles, either porous or glazed, the latter being preferred, even if the cost is a little more, on account of their greater resistance to frost action. These tiles should vary from 3 ins. to 5 ins. in diameter and be placed about 3 ft. below the road surface, or just below frost level. They can be placed at once side of the road, or both sides if necessary, except in places where it may be necessary to carry off water under the centre of the road where springs or spongy places appear.

The pipes should have a fall of at least 2 ins. to every 100 ft. Previous to laying the tiles the bottom of the trench should be brought to a true grade and carefully levelled, so as to avoid any humps in the pipe line. In laying the tile, care must be taken to get the ends to fit closely to each other, and cover the joints with a strip of tarred paper. When filling in the trench, tamp the first few inches of material that is being replaced above and around the tile so as to prevent any possible displacement. Some people recommend filling over the pipes with gravel or small stones, but this is only necessary in certain soils of a stiff clayey nature. The object of subdrainage is to keep the ground supporting the road dry, by carrying off all ground water before it can penetrate the subgrade, also in the spring season, when the frost comes out of the ground, any water resulting from the thaw will be quickly drawn off. Roads which were at one time impassable for wheel traffic, on account of their muddy surface, have, after being properly subdrained, become most satisfactory highways during all seasons of the year.

Surface drainage should now be considered. By this we mean that the crown of the road must be made waterproof, or in such a condition as to shed water easily to open side drains or gutters, which also must be made to carry away quickly any water to the nearest natural outlet.

In constructing an earth road, the cross fall of the surface in level country must not be less than 1 in. in 12 ins.

On hills the camber should be greater, say, 1 in. in 9 ins., so that any water falling on the road will not be allowed to run down the wheel tracks lengthwise of the road and thus create deep ruts.

In many parts of the country one will find V-shaped ditches constructed across the surface of the road. These are more often found in hilly or rolling districts, and are generally spaced about 100 ft. apart and varying in depth from 6 ins. to 12 ins. These drains are not only dangerous, but very uncomfortable to travel over; also hard on

*Paper read before the 3rd Annual Conference on Road Construction, Toronto, March 27th to 30th, 1917.

all vehicles, so should be avoided whenever possible. These can often be eliminated by giving a high crown to the road, good side ditches, and a good smooth surface. Care must be taken to keep all side ditches in such condition that water will not be allowed to remain in them. They must be kept free from weeds and rubbish and have sufficient capacity and grade to carry quickly away the water reaching them under conditions of maximum flow.

In order to ensure a good, smooth, dry surface to the road, one will not have much difficulty after the drainage has been properly carried out. This can be done most economically and successfully by the systematic use of the log drag. It is needless here to go fully into the construction or the use of the drag, as it would be old news to you. However, as this method is the most important in the maintenance of a clay road it will, perhaps, not be out of place to impress on you a few of the most important points connected therewith.

First of all, the drag should be made of light material, preferably cedar or pine, so that it can be easily drawn by one team of horses, and frequently. Remember that the drag is not blessed with brains, and if these are not possessed by the operator one can hardly expect good results. Remember, also, that the road drag will not do the work of a grader.

Drag the surface of the road after each rain storm, not when the road is too soft, but while it is still moist. The man in charge will be the best judge as to the correct time to use it on account of his previous experience of the different characters of the soil. The material moved by the drag in planing off tops of ridges and rough places, should be smeared in a thin, even coat over the surface, fill up hollows and ruts and help to keep a good crown.

Do not attempt to move more earth than is absolutely necessary. The driver should ride, and by so doing he will be able, after a little practice, to manipulate the drag successfully by moving his position backwards or forwards.

A few hours of labor spent at the right time will often save serious destruction which may take much time and money to repair.

All railway companies adopt a strict system of maintenance to take care of their roadbed, bridges, culverts, etc., and as they have proved it good business to them, it surely will apply to the same extent or even more so in highway work.

There are several methods of operation which could be adopted to advantage, one of which I might mention. In case a township has not entered on a county road system, then the council should appoint a road superintendent who must be an experienced and responsible man who will take charge of, and be responsible for, the upkeep of all the roads. His appointment must be permanent, the same as the township clerk and treasurer.

The roads in the township should be divided off into sections of 3 to 5 miles and a man should be engaged for the season to take care of each of these sections.

Often farmers or people residing along the road will be willing to undertake this work. It will not take up the whole of a man's time and as the most efficient work on an earth road should be done just after a rainfall, which is usually a time when the farmer is less able to work to advantage on his farm and when he can often more easily spare a team which could operate the log drag, or do any necessary grading required.

These section men should be provided with rakes, shovels, axes, picks, wheelbarrows, bush scythes, and tool box, and last, but not least, a road drag.

The duties of the men will be to restore the proper shape over the grade, give the surface a good floating, so as to keep it smooth, and not allow any ruts or rough places to form. This can better be accomplished by the drag after every rainfall and when the dirt is about the consistency of putty. Besides this, he must fill up all holes with the same kind of material as the existing road surface, and not on any account with gravel or stone. The men will be expected to put in one or two days each month on the repairs to culverts, bridges, ditches and underdrainage. They must also keep down the brush and weeds, trim all trees, break through the snow in winter, erect snow fences and in general keep the road up to the required standard of the road superintendent and to his entire satisfaction.

It will be difficult to arrange a detailed set of requirements necessary for the maintenance and suitable for every section, as each one may be varied considerably by local conditions.

The road superintendent will have sole control of the section men with regard to road work. He will be expected to visit and inspect their districts periodically and thoroughly study conditions together, so that he will be in a position to advise and guide the council from time to time.

If an inexperienced man is engaged as superintendent, too much must not be expected from him for the first year, but as in all businesses, success is largely dependent on the choice of a capable man in charge.

In placing responsibility on him, he must be given full authority with regard to hiring or discharging men and teams. He must advise the council, the council will decide the work to be done, but the doing of the work will be entirely in his hands.

If statute labor is retained in the township the pathmasters will take the place of the section man previously mentioned.

The road superintendent should acquaint himself with the best methods of constructing and maintaining all classes of road and by knowing how to operate graders, crushers, rollers and all other road-building machinery, so that if at any time he is called upon to improve the earth or clay road surface he will be in a position to undertake the work.

He shall be required to keep an accurate record of all the men employed and work done, so as to be able to furnish the council whenever required with pay-sheets, accounts and vouchers, and be in such a position as to be able to show in detail the character, location and cost of each separate piece of work undertaken, whether for grading, ditching, tiling, dragging, culverts, or other work connected with the care of a road.

NEW ZEALAND IRON AND STEEL ENTERPRISE.

A company has recently been formed in New Zealand, with a capital of £70,000 (about $340,000), with the object of producing iron and steel from magnetic and titaniferous iron sand, of which there is a large deposit on the coast at Taranaki, near New Plymouth, North Island. Works are being erected at New Plymouth. The present intention is to install a furnace capable of dealing with 70 tons of iron sand weekly, but plans have been drawn up for the installation at a later date of an additional furnace capable of dealing with 200 tons weekly. The company claims that pig iron can be produced from these iron sands at a cost not exceeding £3 ($14.60) a ton. The production of steel is also contemplated, and it is intended later to form a new company to carry out this development. Meanwhile, the company will proceed with the production of pig iron for foundry purposes.

Editorial

OTTAWA AND GOOD ROADS.

Federal aid is urgently needed in the building of good roads in Canada. It is appropriate, therefore, that the fourth annual meeting of the Canadian and International Good Roads Congress be held in Ottawa next week.

Not since Confederation has the Dominion of Canada contributed to the construction or maintenance of the King's highway. A bill allowing $30,000,000 for federal aid was defeated by the senate a couple of years ago on account of the senators not being able to agree as to how the money was to be appropriated. A new bill should be brought down for this amount, or even more, to be granted to the provinces *pro rata* according to population. Both the sentimental and practical value of roads, not only in peace but also in war, have been established beyond dispute. The good roads of France saved Paris.

Looking at the matter strictly from a business standpoint, it is easy to demonstrate that the expenditure of $30,000,000, or many times that amount, on good roads by the federal government would be a mighty good investment. Experience in the United States, and also upon a smaller scale in Ontario and Quebec, shows that production increases and farm properties improve in value with the construction of good roads. A few statistics taken from the last census (1911) will show just what these increases in value would mean to Canada. There were then about 703,000 farms in this country valued at approximately 4¼ billion dollars. An increase of fifty per cent. in this value—an increase attainable by an adequate system of good roads—would mean that the wealth of the nation would be enhanced by over two billion dollars.

Besides the increases in regard to improved land there is also to be considered the influence of good roads upon the farming of unimproved land. At the time of the last census the unimproved farm land in Canada was worth about $13.50 an acre compared with $51 an acre for improved land, a difference in value of $37.50 an acre. There are about 61,240,000 acres of such land in the farms of Canada. The building of good roads which would allow for the marketing of sufficient products to make it profitable to cultivate this land, would mean the addition of another 2¼ billion dollars to the wealth of our country.

These figures deal merely with direct additions to the nation's wealth caused by increases in value of farm property, and, stupendous as they are, amounting to 6½ billion dollars, they are no more important than the other benefits derived from good roads, such as the large increase in manufactured products which would result from greater facility in marketing same among the agricultural population, the improvement in the affairs of schools and churches, the greater health and pleasure of the entire community, the advertising which Canada would get among tourists from United States and other countries, and the advertising which the various sections of the Dominion would get among the tourists from the other sections.

Neither does it take into account the considerable improvement which would be made in our railway freight statistics, and in immigration. One of the causes of the present railway situation in Canada is the lack of sufficient good roads as feeders to the railways. In preparing for after-the-war problems and for attracting a fair share of American immigration, what stronger factor could there be in inducing these new people to settle on the land instead of congregating in cities, than for the Dominion Government to help in providing an adequate system of roads which would enable them to get onto the land, to market their products, and to be willing to remain in farm life contentedly, owing to easy access to towns and cities whenever desired?

ONTARIO AND QUEBEC ROADS.

Besides the question of federal aid, there is another reason why Ottawa is the ideal city in which to hold the Canadian good roads congress this year. On the borderland of both Ontario and Quebec, forming a federal district which virtually and practically is not distinctly a part of either province but a link between them both, Ottawa is an ideal place for a congress which will exemplify work that has been done by Ontario and Quebec in the good roads movement. These two provinces have been the leaders in the movement in this country.

This is the tenth anniversary of the passing of the law which marked a new era in road building in Quebec. This law has since been amended and during the last five years far greater sums have been spent by that province than were spent in the initial half of the past decade. The first time the million-dollar mark was reached in Quebec Province road expenditures was the year 1912-13. This increased to over four million dollars the following year, and to over six million in 1914-15.

The laws relating to highways date from the founding of the French colony in Canada. Under the French regime the highways were all under the control of the Grand Voyer. After the fall of the gallant Montcalm the highways were practically neglected until 1840. Thirty years later municipalities were given sole control of the roads, and while this control has continued during the last ten years, assistance to these municipalities—even to townships and parishes—and the creation of an able provincial roads department to co-operate in the work, have helped the municipalities in building and maintaining good roads.

During the past decade over 2,000 miles of macadam and gravel roads have been constructed or improved in Quebec. The King Edward Highway, the Sherbrooke-Derby Road, the Montreal-Quebec Road, the Chambly Road and the Levis-Jackman Road have been built. Several other roads are proposed, including Montreal to Hull, Three Rivers to Grand-Mere, Levis to Nicolet, and Nicolet to Rimouski.

While Ontario as a province has been behind Quebec in road development, it has been a close second, and if total expenditures on all pavements, both streets and roads,—by all parties, both provincial and municipal,—are considered, Ontario probably leads, as over ten million dollars a year has been expended for many years past for streets and roads in Ontario.

For several years approximately a half million dollars per annum has been spent on trunk roads in New Ontario, and another half million dollars on colonization roads. During the last calendar year about $300,000 was expended

in aid to counties, which would involve an outlay by the counties themselves of another $450,000. The Ontario system does not recognize any municipality smaller than a county.

The Toronto-Hamilton Highway is the only trunk road of great importance that has been built in Ontario within the past few years, but a Provincial Road from Ottawa to Windsor has been planned and will be gone ahead with as rapidly as finances permit under war conditions. In Ontario also there is an energetic highway department, which is planning far ahead, at the same time closely supervising existing roads.

Both the Ontario and Quebec governments are doing their best to eliminate toll roads and toll bridges. A considerable proportion of the federal aid could be used advantageously in the improvement of bridges. A speaker at the last road congress stated that about ten thousand wooden bridges and culverts had been replaced by steel and concrete in Quebec Province in the last ten years.

Many thousands of miles of roads in Canada require construction or reconstruction. Broadly speaking, we might almost say that Canada has no roads; the era of road building in Canada has only begun. The support that was accorded the Canadian Road Congress in Montreal in 1914 and 1916, and in Toronto in 1915, is an indication of the interest that the people of Quebec and Ontario are taking in good roads, and there is no doubt but that similar interest will be shown in the meeting at Ottawa next week.

ANOTHER MONTREAL DRAMA.

Life must be interesting for the members of Montreal's Works Department and Board of Control. To say the least, it never becomes monotonous. Investigations, suits, scandals, charges, court trials and other incidents of municipal regime follow along with startling rapidity in our eastern metropolis. But the scenery is always the same. Different actors, various lines and new stage managers enter the limelight, but the background of alleged graft never changes.

The latest drama might be entitled, "Spending $5,000, or a Closed Specification for Flushing Equipment"—in three reels. The scenario follows:—

First Reel—Views of Montreal's streets, showing the mud for which said streets are noted in the springtime. Close-up of city engineer reaching decision to call for tenders on motor-driven flushing machines, the most modern and best method of street cleaning. Enter Chas. Hvaas, of New York City, strongly determined to have "Hvaas" superstructure equipment specified, whatever truck or chassis is purchased.

Second Reel—View of Board of Control meeting. Tenders received. Complaints of favoritism and "absolute specifications." New tenders called on revised specifications which other manufacturers allege admit only "Hvaas" equipment. Chas. Hvaas quotes Montreal truck dealers $2,500 per set of equipment, compared with $1,300 quoted for the same equipment before tenders were called. Dealers complain. Hvaas says: "It cost me a lot of hard work and $5,000 to have my specifications passed and if I give the price quoted before, who will pay me back the $5,000?" Hvaas later lowers price somewhat but is still higher than original figure.

Third Reel—Flash-back to Board of Control. Second tenders received. Demand for investigation of Hvaas' statements. Cut-in of meeting of investigators. Hvaas on stand. Admits statement, but claims the $5,000 was spent on hotel bills, salary, etc., during three months' work of persuading Montreal officials to use his specifications. Says he never gave a nickel to any city executive. Details of notes, loans and much of the private life of a controller and his former secretary, now an agent for the Hvaas Co., enliven the scene and permit a display of fine emotional acting. Return to original setting:—Board of Control calls for third tenders, manufacturers still complaining about the specifications.

The failure of this drama to secure popular applause will be its lack of new "props" and of new "location." Every up-to-date movie director knows that the public tires in time of seeing the same old background even though the story varies. Why doesn't Montreal shift the scene and play "The Open Specification, or Always Giving Everyone a Square Deal"?

PERSONAL.

T. S. HUSBAND has been appointed waterworks engineer at Ladner, B.C.

CARLTON MILLER has been appointed town engineer of Bridgeburg, Ont., to succeed EDWIN J. JUKES, who recently resigned.

M. LEIGHTON WADE, for the past two years electrical superintendent at Duncan, B.C., has resigned, and will re-enter the plant construction field.

FRANCIS C. McMATH, president of the Canadian Bridge Co., Walkerville, Ont., was recently appointed a member of the Detroit Municipal Street Railway Commission.

A. S. CLARSON, engineer of the city of Verdun, Que., has been appointed consulting engineer to the city in connection with the proposed underground conduit system, estimated to cost $200,000.

STEWART JONES, of Welland, Ont., has been appointed inspector of power plants for the Hydro-Electric Commission of Ontario. For the last eleven years he has been with the Hydraulic Power Company of Niagara Falls, N.Y.

R. H. STARR has severed his connection with the engineering staff of the Toronto Hydro-Electric System, and has accepted a position as sales engineer with the Toronto sales office of the Moloney Electric Company of Canada, Limited.

P. W. GORDON, who has been with the Imperial Oil Co. at Calgary for eight years, has been promoted to the managership of the Saskatoon territory. Before his departure from Calgary he was presented with a watch and chain and Masonic charm by the staff.

Capt. RAYMOND TYRWHITT, of Toronto, who joined the 215th Battalion at Brantford, Ont., as a lieutenant, and was subsequently promoted to be captain, has been appointed adjutant of that unit. Capt. Tyrwhitt was a member of the School of Applied Science, class '15.

Lieut. FRANKLIN ROY MALCOLM, of Locust Hill, Ont., a student at the School of Applied Science, Toronto, has been appointed second lieutenant in the 25th Northumberland Fusiliers. He went to England with the second draft from the Overseas Training Company.

FRANK BARBER, A.M.Can.Soc.C.E., and R. O. WYNNE-ROBERTS, M.Can.Soc.C.E., consulting en-

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HALIFAX OCEAN TERMINALS

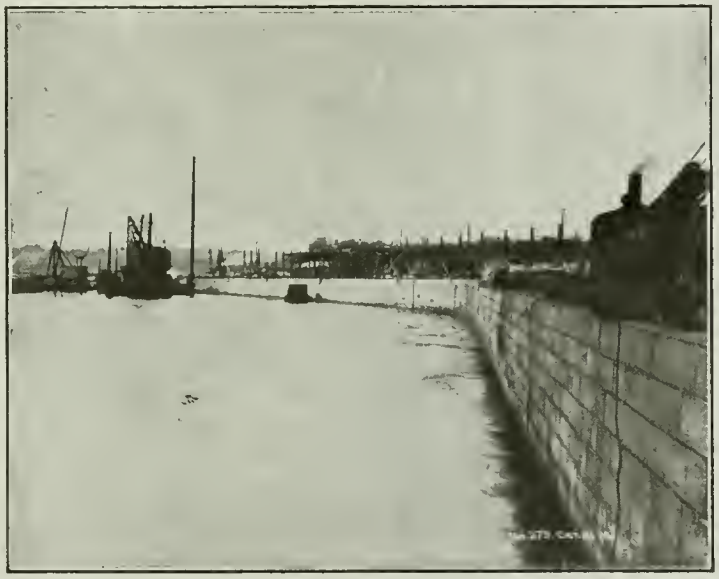
DETAILS OF CONSTRUCTION METHODS USED IN BUILDING OF CONCRETE QUAY WALLS—MANUFACTURE OF CONCRETE BLOCKS—MATERIALS OF CONSTRUCTION

By A. C. BROWN, A.M.Can.Soc.C.E.

THE terminals consist of a passenger landing quay 2,006 feet long, five piers 1,250 feet long by an average width of 350 feet, and a breakwater about 1,600 feet long, on the north side of which will be constructed later two steamship berths. On the north side of the first basin are two berths, 500 and 700 feet long. With the exception of these two berths, which will have 30 and 35 feet at l.w.o.s.t., 45 feet at l.w.o.s.t. will be provided at all the berths. The whole system will be equipped with modern sheds, freight handling appliances, grain elevators, ample tracks and all requirements pertaining to modern terminals.

In order to provide railway connections with the new terminals an extension of the existing Intercolonial Railway was necessary. Many locations for this extension were studied, and finally, after careful consideration, it was decided to construct a line diverging from the Intercolonial Railway at Fairview. Great care has been taken in the location and design of the bridges, for grade separation of railway and highway traffic to preserve as far as possible, not only the beauties and amenities of the Northwest Arm, which from a tourist point of view is the city's greatest asset, but also of the suburban district through which the railway passes. From the crossing over Chebucto Road the railway follows the east side of the Northwest Arm to Maplewood, and from thence passes in an easterly direction in a deep cutting to the site of the terminals. Grade crossings are eliminated, the railway crossing over the highways at Fairview Road by steel girder spans with concrete abutments and over Chebucto Road by steel girder spans encased in concrete, the remaining highways and streets being carried over the railway on ornamental reinforced concrete arches.

The railway is about 5 miles long and is to be double tracked throughout, with 4 tracks at Bower Road and branching out into the yard with 16 tracks at Tower Road. The maximum grade for east-bound traffic is to be 6 10 per cent. compensated .04 per cent. per degree of curvature and the sharpest curve will be 4 degrees with standard spirals.



Showing Portion of Finished Wall.

Railway.—The work of constructing the new railway was commenced towards the end of July, 1913, at Fairview, and a month later at the harbor end.

The shooting of the rock in the Fairview end of the cutting presented many difficulties, the rock being very faulty, containing pockets of rotten-disintegrated rock, mud, clay, gravel and sand, as well as water. The cut was drilled and shot no less than three times before it could be completely excavated.

The first time holes were drilled with well drills at 9-foot centres in rows 16 feet apart. It was intended to spring these, but most of them caved in and were lost; as many as possible, however, were shot and a shallow cut taken.

The second time the holes were drilled 10 feet apart in rows 8 feet apart to 6 feet below subgrade and shot without springing, but this was not entirely successful.

The third time the holes were drilled 10 feet apart in rows 5½ feet apart, staggered and to 6 feet below subgrade without springing. Even this did not break the bottom of the cut properly, and the further use of piston drills was necessary for that purpose. A low freezing explosive was used on account of the presence of very cold water in many of the drill holes.

Most of the shooting was done in blasts of from 3 to 8 tons of 60% forsite (low freezing) calculated on a basis of from 1⅛ to 2 lbs. of explosive to the cubic yard of material blasted, according to the nature of the rock. It was very clearly demonstrated in the extremely shattered rock encountered that the electrically driven drills were much superior to the steam-driven. Owing to the impossibility of keeping the steam at an even pressure the time of the stroke of the drill constantly altered, and if it was working slowly when it passed from a hard into a seam of disintegrated rock it jammed. With the electric drills, however, as the strokes were steady, very little of this trouble was encountered. It is worthy of record that although most of the blasting was done in close proximity

*Abstracted from paper read before the Canadian Society of Civil Engineers, Montreal, April 5th, 1917.

to houses and streets, very little damage was caused, and there were no serious accidents either to the general public or to the workmen employed.

Bridges.—In connection with the railway running in from Fairview to the terminals, sixteen bridges are called for. Of these, fourteen are highway bridges, arch type, constructed entirely of reinforced concrete. The one carrying the Halifax Ocean Terminals Railway over the streets at Fairview is to be built of plate girders in a single span. This bridge will have a concrete deck only.

The other, carrying the railway over Chebucto Road, is to be built of plate girders in three spans; that is, two sidewalk spans and the roadway span. This bridge will be entirely encased in concrete.

The single spans for highway bridges vary from 60 ft. to 144 ft.

At Young Avenue, the double span arch is to be approximately 225 ft. between main abutments.

All abutments and wing walls are built on solid rock and are of mass concrete.

The aggregates for the concrete were obtained from a beach at Seaforth, on the eastern shore of Nova Scotia, and shipped in flat cars over the Canadian Government Railways via Windsor Junction to the different bridge sites. There the materials were hoisted to the top of the cut by means of a clamshell bucket, operated by an ordinary stiff leg derrick.

The following mixes of concrete were used: 1 : 2½ : 5, 2-inch mesh in main abutment and wing walls; 1 : 2 : 4, 1-inch mesh in arch ribs and spandrel walls; 1 : 1½ : 3, ½-inch mesh in handrailing.

Dredging.—A very important item was the dredging and especially the rock and deep-water dredging. The more or less soft material overlying the rock in basins Nos. 1 and 2 was first removed by the dipper dredge, "King Edward," equipped with a 5-cubic-yard bucket. This dredge had a maximum dredging depth of 50 feet and a minimum of about 15 feet.

After much consideration and comparison of systems of drilling in various classes of rock and of the results obtained, drill boat No. 1 and afterwards drill boat No. 2 were constructed.

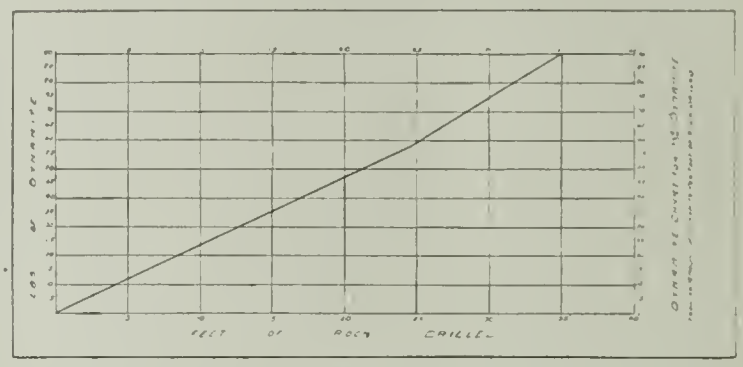
Drill boat No. 1 consists of a wooden scow 35 feet wide by 90 feet long, fitted with 7 steam drilling machines with 5⅝-in. bits and 6-in. cable, 4 spud anchors with spud engines, two winch engines, locomotive boiler and electric light generating set.

Drill boat No. 2 is similar to No. 1 only larger, consisting of a wooden scow fitted like No. 1, but containing 10 drills, 7 feet apart.

The rock encountered is similar to that found on the railway and consists for the most part of slate or shale with iron stone and an occasional trace of trap rock and quartz. It lies in very irregular inclined strata, being seamy and much broken, so much so that it is necessary to case all the holes with a 6-in. case pipe and to drive it sometimes for fully three-quarters the depth of the hole. This effectually cuts off the flow of sand, clay or mud contained in the seams of the rock, and so prevents the drills jamming. The holes are kept clean by means of a sand pump.

When the rock drilling and blasting first started the holes were drilled in rows 7 feet apart, and about 2¼ pounds 60 per cent. dynamite used to the cubic yard of material blasted. This was found to be excessive, and lated the holes where the rock was deep were spaced 10 or 11 feet apart, and about one pound of 75 per cent. dynamite used to the cubic yard of material blasted. The dynamite chart shows the amount of dynamite to be used per foot of hole and is worked out on this basis. (Fig. 2.)

Outside the wall foundations the drill holes are drilled to from four to six feet below grade to ensure that the rock is broken fully to grade and that the dredged depth can be obtained with comparatively easy dredging. On the site of the wall foundations and within 10 feet of them the holes are drilled 3½ feet below grade at 7-foot centres, so as not to injure the foundations.



This system of drilling in the rock encountered has been very successful, and as much as 6,000 cubic yards of rock have been drilled and blasted by the two drill boats in a week. Very little of the broken rock is larger than one cubic foot.

Quay Walls.—For permanent work the use of timber for the sub-structure of the quay walls in Halifax harbor was not possible, owing to the activities of both the "limnoria ligorum" and the "teredo navalis," two marine insects which are very active in attacking timber.

A careful examination of the existing timber wharves along the water front showed that the limnoria was particularly active, and that the life of timber in Halifax harbor was comparatively short. Evidence of the presence of teredo was found, but to a much less degree than the limnoria. Experience has shown that creosoted timber is able to withstand the attacks of these marine insects for a much longer period than untreated timber, but even creosoting does not render timber immune from attack.

Concrete is not subject to attacks from any marine insects and with proper precautions taken as to mixing, proportioning and placing, is in sea water practically free from disintegration. Due to climatical conditions in Nova Scotia, however, concrete between high and low water will break up through mechanical action, due to frost, when the temperature approaches zero. It was, therefore, decided to build the quay walls of concrete and face them with granite from one foot below l.w.o.s.t. to quay level. A careful comparison of designs of open work, reinforced pile and cylinder construction, mass concrete, concrete block and concrete caisson construction led to the design and adoption of a quay wall constructed of cellular reinforced concrete blocks filled with mass concrete and broken rock, whereby it was hoped to combine all the advantages derived from the use of reinforced concrete and to deposit the mass concrete under water under conditions which were as nearly as possible ideal, the blocks acting as permanent forms.

The standard blocks are 31 ft. x 4 ft. 1½ ins. x 21 ft. 10 ins. cellular with diaphragms 8 ins. thick and reinforced principally with ⅝-in. square twisted steel bars.

It will be noticed that the front and middle compartments are square and connected one with another by tri-

angular holes and are to be filled with concrete. The remainder of the compartments are circular and are to be filled with broken rock, being designed circular so as to better withstand the bursting pressure due to the broken stone filling. Each block contains eight 10-in. grout holes. There are only five shapes of blocks. The bottom course 34 ft. x 3 ft. 4 ins. x 21 ft. 10 ins., the second 31 ft. x 3 ft. 6 ins. x 21 ft. 10 ins., the standard blocks 31 ft. x 4 ft. 1½ ins. x 21 ft. 10 ins., the two top blocks 26 ft. x 4 ft. 1½ ins. x 21 ft. 10 ins., these latter being made by leaving out the front compartments of the standard blocks and the special blocks with a rounded corner to form the corners of the pier and landing quay. The blocks, which contain about 30 yards of concrete and from 2½ to 3 tons of reinforced steel and weigh about 62½ tons, are manufactured in a block yard on the site of the works.

Steel forms consisting of four ridged outside pieces and collapsible inside pieces are used. The forms are bolted down to the platforms and held together at the top by means of clamps. In stripping a block, each outside form is lifted independently, and those in each compartment are collapsed and lifted out.

The arrangement of reinforcing steel in the blocks is very simple, consisting mostly of long bars running right through them.

The simplicity of the system of reinforcement is illustrated by the fact that the reinforcement for a block is erected in 30-man hours. Little difficulty is experienced in making ten blocks per day, and under very favorable conditions as many as sixteen have been made in a single day. After seasoning for a month the blocks are either stored in a storage yard or placed into the quay walls. About 3,600 blocks are required to complete the quay walls for the first unit and all but about 800 have now been made in two working seasons.

The quay walls are constructed of stacks of reinforced concrete blocks, placed one directly above the other, and securely bonded and bedded by means of mass concrete in the front and middle compartments and by old railway rails grouted into the 10-in. grout holes.

The method employed in constructing the quay walls is as follows:—

The foundations are prepared and concrete pedestals 5 ft. x 6 ft. from a few inches to several feet deep are constructed every 22 feet along the line of the wall; upon these pedestals the bottom blocks rest, the adjacent corners of successive stacks of blocks resting on the same pedestals.

When the pedestals are more than 4 inches deep they are connected by a concrete wall about 2 feet thick at the top. The wall is left 3 inches lower than the pedestals.

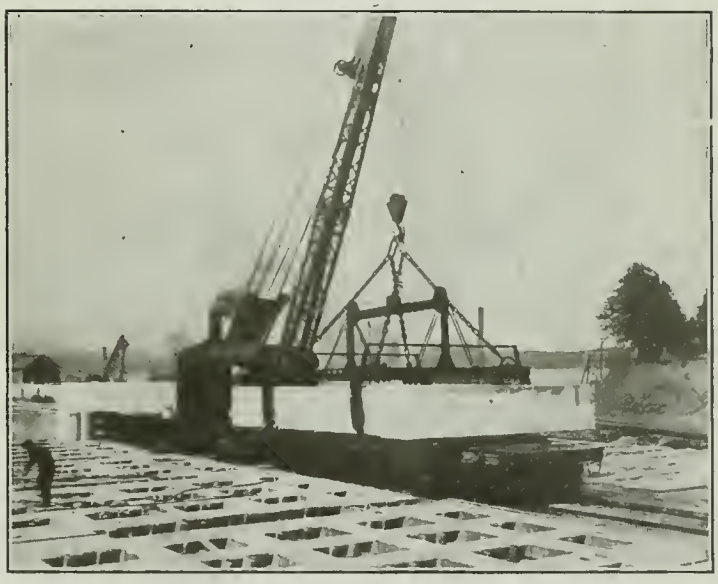
By means of the 150-ton locomotive crane, sufficient blocks are loaded on to flat cars to complete one stack. The crane then travels to the scene of operation and the blocks are sent out to it one by one. They are lifted and put in position just touching the guide posts and then lowered into place. As soon as the block is on the bottom, the boom of the crane is lifted a few inches and the block raised about 2 feet and finally lowered into place. This has the effect of bringing the block hard up against the guide posts. The crane travels out over the empty stacks of shells, a very important construction feature which does much to promote the progress of the work.

Following the block-setting comes the filling of the stacks with concrete. Before concreting takes place, bags of sand or wooden shutters are placed along the bottom of the wall between the pedestals back and front to prevent the concrete running out and a small quantity of rubble is placed between the stacks for the same purpose.

The concrete, consisting of 1 part cement, 2½ parts sand and 5 parts broken stone, is conveyed from the yard mixing plant at night, or when blocks are not being made, in 1 cubic yard bottom-dumping buckets and placed by means of a locomotive crane standing on the walls. Great care is taken that the buckets do not deposit their concrete until they are on the bottom. Two floating mixing plants are also used for this work at times. The concrete in the front pockets of the blocks is left 6 inches below the top of the standard block, so as not to interfere with granite setting. Old railway rails are then placed in the grout holes extending from top to bottom of the stacks of blocks and grouted in with a 1:2:4 concrete.

After the concreting is completed dredged rock is placed in all the circular compartments of the blocks and the wall is then ready for the granite face work and mass concrete top wall.

To commence the block setting timber trestles were built to the shore ends of north quay basin No. 1, the north and south quays of pier "A," and to a point near the centre of the bulkhead passenger landing quay and block setting has taken place from all these points.



Crane Loading Block onto Flat Car. Note Specially Designed Lifting Tongs.

Foundations.—There are three classes of foundations encountered on this work. Most of the walls are founded upon rock; about 600 feet at the centre of the passenger landing quay and the pier head are on rubble mounds, and about 400 feet on the passenger landing quay on a glacial deposit of red boulder clay.

Where rock was encountered above grade it was removed by dipper dredges, the surface cleaned and the pedestals built by means of a large diving bell.

The diving bell consists of a large steel chamber 38 ft. x 26 ft. x 7 ft. high, and is provided with separate man and material shafts and locks. It is capable of sinking and refloating itself by means of a water ballast tank and can work in any depth of water from 25 to 55 feet.

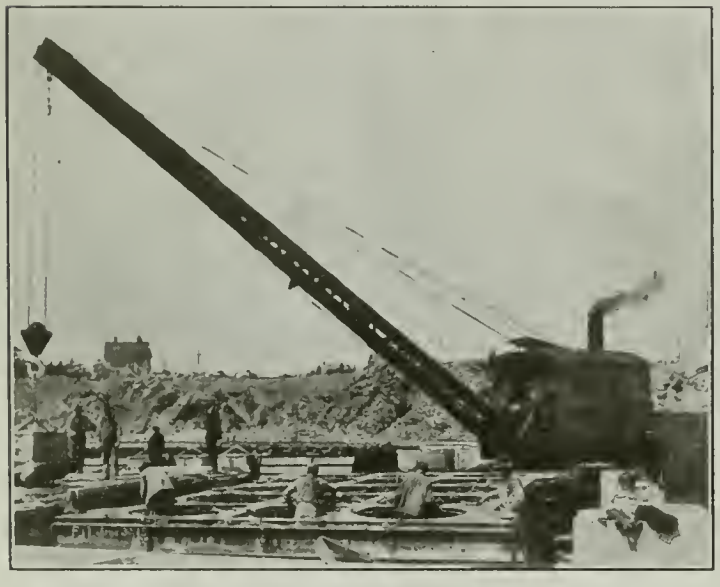
Eight or ten men usually work inside the diving bell, the water being kept out by compressed air. The bell is tended by a wooden scow 100 ft. by 32 ft. 8 ins., fitted with high and low air compressors, pumps, electric light,

a ½ cubic yard concreting mixer and a steel frame derrick of 20-ton capacity.

For the first few months clay was packed around the cutting edge of the bell, all the water pumped out and the concrete pedestals constructed in the dry. This mode of procedure, however, took considerable time, and there was always the danger of the clay bank breaking and allowing the water to rush in. It was, therefore, decided not to dry out the working chamber and the bottom was from that time covered with from 6 inches to 2 feet of water.

Immediately under the material shaft the ground was left slightly higher than the cutting edge. On this piece of dry ground the concrete was deposited. Forms made of sacks of material collected while cleaning the bottom were built round the pedestals and concrete shovelled into them commencing at one corner, until it showed above water. The remainder of the concrete was shovelled on to this and allowed to push out until the pedestals were completed, thus ensuring that the cement would not be washed out.

This method gave complete satisfaction. As concrete sets very quickly under air pressure, it was possible to



Blocks Before Leaving Yard.

strip the forms off the pedestals in six hours even with a pedestal 3 or 4 feet high. The water was then allowed to rise slowly in the bell and the bell moved.

There was only one foundation which caused any trouble and calls for special mention, and that was for the first stack of blocks on north quay basin No. 1, where it was found that the rock at the front of the wall slipped down suddenly for a depth of 7 feet below foundation level.

In order to set the bell on this foundation the hole was filled with granite boulders, and the bell then set with its front edge resting on them, and its back edge on the solid rock. The water was then expelled from the working chamber and the bell tilted forward by removing pieces of granite until it was 3 feet out of level. Fortunately the front edge of the bell just rested upon two large granite boulders, so all the granite inside the line of the wall could be removed. When this had been done a clay bank 4 feet high was built from the bottom of the hole to the cutting edge and all the water expelled.

By this means it was possible to excavate the rock along the front of the wall forming a level strip 7 feet wide at the bottom of the hole to ensure a good footing. This was a somewhat interesting and delicate operation, as the men were working 4 feet below the cutting edge with only a light clay bank to keep the water out.

Wooden forms were then placed along the front of the bell and a concrete wall 8 feet thick constructed up to the level of the remainder of the foundation, and on this wall the front pedestals were made. It was found in connection with the bell work that if the rock had been properly dredged to grade by the dipper dredge 22 lineal feet of foundation could be prepared with the bell per day.

Materials of Construction.—Cement: All the cement used on the works is manufactured in Canada, at Montreal and Belleville. The Belleville cement, which contains a low percentage of magnesia, was used in concrete which would come in contact with the salt water.

Aggregate for Concrete: Beach sand and gravel is used in all concrete work. This material is obtained from a beach purchased by the contractors at Lawrencetown, about 16 miles east of Halifax. With careful inspection it was found possible to use run of beach material for all the mass concrete work.

Reinforcing Steel: The reinforcing steel is manufactured at New Glasgow and Sydney, Nova Scotia.

Granite: All the granite is obtained from Purcell's Cove Quarry.

Cast Iron: The castings for the mooring hooks are all made locally.

Features of Design.—The smoothness and facility with which the harbor works have been carried out and the general standard of excellence attained have so far amply justified the main features of the design of the quay walls and breakwater and the location. The principle of using the largest possible blocks for quay wall construction, providing the weight does not exceed the capacity of reasonable and, if possible, standard equipment, has been further illustrated and the results have even exceeded expectations. It would be impossible to set smaller blocks with greater accuracy and at a faster rate. Experience has shown that the large reinforced concrete blocks can be set as quickly as the small granite corbel course blocks.

The cellular construction of the blocks has made it possible to manufacture a block about three times as large as a mass concrete one of the same weight, and has thus cut the amount of block setting to one-third.

The width of the wall, namely, 31 feet, has eliminated the use of expensive temporary staging for carrying the block setting cranes and at the same time has provided foundations for the front row of freight shed columns, which otherwise would have to be provided independently at considerable cost. Perhaps the most interesting and certainly the most important feature of the design of the blocks is that an enormous saving in foundation work has been effected. Whereas it is usually necessary to carefully construct a level foundation for the full width and length of the wall, by means of concrete in bags or mass concrete carefully levelled, all that is necessary with the cellular blocks is to level the small areas on which the corners of the bottom blocks rest, that is, a pedestal 5 ft. x 6 ft. back and front of the wall is constructed every 22 feet, and the remainder of the foundation allowed to remain as left by the dredges, with the exception of a little cleaning, as previously described.

The harbor works are also sufficiently advanced for it to be safely recorded that the main features of the design are even better suited to conditions found at the site of the terminals than was anticipated.

CANADIAN RAILWAY PROBLEM.

SIR THOMAS TAIT has just written a paper offering a new solution of the Canadian railway problem, advocating one united system of railways in Canada. Sir Thomas has had long and valuable experience in railway management in Canada and Australia, so his paper is authoritative and well worthy of due consideration along with any other schemes suggested. His paper in full is as follows:—

The Dominion of Canada at the present time owns or controls and operates a railway system, the main lines of which extend from Sydney, Halifax and St. John on the Atlantic seaboard to Quebec and Montreal, and from Quebec to Fort William and Winnipeg, and there is, therefore, to-day in Canada the administration by the State of about 4,000 miles of railway and competition between company railways and a State owned and operated railway system extending more than half way across the continent.

In view of certain conditions which, it is to be regretted, prevail in this country and in which there appears no promise of early improvement, the efficient administration along business lines of State railways in Canada by the government, even by means of a so-called "independent" board of commissioners can not be confidently anticipated. It is generally the experience in democratic countries having State railways that it is impossible to eliminate political influence, exerted if for no other reason than to promote and advance the interests of the political party in power, and, undoubtedly in such countries as the United States and Canada, where political partisanship runs so strong and political patronage has so long been the custom, prudent and efficient management of railways by the State would be found sooner or later to be impracticable owing to political interference and influence.

Competition between State owned and operated railways and company railways is inequitable and unfair to the private investor in the latter. Money for construction and equipment can, generally speaking, be borrowed or obtained by the State on considerably better terms than by companies, and, therefore, State railways are not expected or required to earn as large a return on their cost as investors in company railways, especially shareholders, look for and should receive. If everything else, therefore, be equal, an important and improbable proviso—the rates and fares on State railways do not require to be as high as on company railways. Due to the exercise of political influence, rates and fares on State railways are liable to be reduced and indeed as a rule are reduced, and train services and other facilities are provided beyond what the traffic and other conditions warrant, and these lower rates and fares and these unjustified facilities must be conceded by competing company railways if they are to retain their fair share of the traffic.

In view of the possibility, if not the probability, of the Dominion being compelled to take over the Canadian Northern system and the Grand Trunk Pacific Railway from Winnipeg to Prince Rupert with its branch lines, the question arises whether in such event the difficulties and disadvantages of State administration, on the one hand, and the injustice of State competition with private enterprise, on the other hand—both of which will be greatly aggravated and increased should the present State railway system be extended from Winnipeg to the Pacific Coast and throughout our Western Provinces—might not be avoided.

The following is an outline of a scheme whereby both the advantages which may be derived from the ownership of railways by the State and the good results which should accompany efficient administration by a company may be obtained and to these be added the great advantages, including a very large saving in operating expenses, which would result from all the more important railways of Canada being managed and operated as one great system:—

(a) It is assumed that the Dominion can acquire all the common stock of both the Canadian Northern and the Grand Trunk Pacific Companies for possibly a nominal consideration or, having regard to the magnitude of the scheme, for a comparatively small sum.

The Dominion to take over all the assets and assume all the liabilities of the Canadian Northern and the Grand Trunk Pacific systems and to guarantee interest on their bonds and debenture stock—supplemental to and not in cancellation of existing provincial and other guarantees of such securities.

(b) The Dominion to lease the Canadian Pacific Railway system in perpetuity for a rental equivalent to an agreed annual return on its common stock and to guarantee the payment of all dividends or interest on all the securities of that system which are senior to its common stock and to assume all the liabilities of that company, including all its guarantees on the securities of other railway companies, and the payment of all rentals for which the Canadian Pacific Railway is responsible. The Dominion to take over all the assets of the Canadian Pacific Railway Company, except those which are not closely connected with the operation of its railways and connections, which assets would be transferred to a separate company for the benefit of the Canadian Pacific shareholders.

These excluded assets would include: All lands, except those specified as "Surplus Lands" in Schedule "B" of the Company's Annual Report; interest in town sites; timber and mining rights; collieries and timber mills; improved farms and live stock; natural gas and petroleum rights; investments in Consolidated Mining and Smelting Company and in West Kootenay Power and Light Company; investments in coal and other mines; balance at credit of special income account; proceeds of land sales; deposits and loans; cash on hand and in banks, etc., in excess of current liabilities.

(c) The Dominion to lease the Grand Trunk system in perpetuity for a yearly rental equivalent to certain rates of dividends per annum on its preference and common stocks to be agreed upon, and to guarantee the payment of all dividends or interest on all the securities of that system which are senior to its preference and common stock, and to assume all the liabilities of that company, including all its guarantees on the securities of other railway companies and the payment of all rentals for which the Grand Trunk Company may be responsible. The Dominion to take over all the assets of the Grand Trunk Company.

(d) The five systems, *viz.*, the existing Government system, the Canadian Northern, the Grand Trunk Pacific and the Canadian Pacific and Grand Trunk systems (hereinafter called the "Whole System") to be administered for and on behalf of the Dominion, under an agreement with the Dominion, by a company known as the "Canadian Railways Company," to be incorporated and constituted as follows:—

(e) The company to be incorporated as above to have a capital of, say, ten million dollars and a board of directors of nine members, hereinafter called the "Board."

Fifty-one per cent. of the capital to be subscribed and paid for and to be held by the Dominion, and the balance —forty-nine per cent.—to be subscribed and paid for and to be held exclusively by citizens of Canada.

The Dominion to guarantee five per cent. per annum dividend on the stock of the said company.

Four of the nine directors to be appointed by the Governor-General-in-Council, four by the citizen shareholders of the company, representing forty-nine per cent. of the stock, and the ninth director to be appointed by the Supreme Court of Canada. The directors appointed by the Governor-General-in-Council and by the Supreme Court not to be interested directly or indirectly in the stock of the company.

No corporation, firm or individual to be interested directly or indirectly in more than one hundred shares of the citizens' stock. No stock to be transferred without the consent of the board.

The directors appointed by the Governor-General-in-Council to hold office, one for five years, one for six years, one for seven years and the fourth for eight years, and to be eligible for re-election—subject, however, to dismissal by the Governor-General-in-Council in the event of misconduct or incapacity, with right to appeal in such case to the Supreme Court of Canada. These four directors to be the most capable railway administrators obtainable—one of them with experience in operating, one of them in traffic, one of them in finance and accounting and the fourth in legal work.

The directors appointed by the citizen shareholders to be elected annually.

The director appointed by the Supreme Council to hold office for ten years and to be eligible for reappointment, subject, however, to dismissal by the Governor-General-in-Council in the event of misconduct or incapacity with right of appeal in such case to the Supreme Court.

Vacancies due to death or resignation to be filled by the Governor-General-in-Council in the case of a director originally appointed by him, in the case of a director appointed by the citizen shareholders by the other three similarly appointed directors until the next annual meeting of the company and by the Supreme Court in the case of the director appointed by it.

The chairman and vice-chairman of the company to be appointed by the Governor-General-in-Council from among the four directors similarly appointed and to hold office for eight and seven years, respectively. The chairman to be the chief executive officer of the company. The vice-chairman to assist the president and to represent him in his absence.

The salaries of the members of the board of directors appointed by the Governor-General-in-Council to be sufficient to secure the best men for the positions and the salaries of the other directors to be such as to make it worth the while of able and reliable men to become members of the board.

The board to control and direct the policy of the company and to have complete control of the appointment and work of the officers and employees of the company.

In any year in which the net revenue of the whole system is sufficient to pay all the rentals and other charges payable by the Dominion in respect of the whole system, including interest at an agreed rate on the amount invested in the existing government system and the interest payable on additional capital expenditure (see Clause "f"), all hereinafter called "fixed charges," the chairman and vice-chairman and other members of the board shall receive a bonus equivalent to an agreed percentage of their respective annual salaries and the citizen shareholders an agreed increase in their dividend, and in the event of the net revenue exceeding the said fixed charges in any year by a percentage to be fixed, the said members of the board shall receive an additional bonus equivalent to an agreed percentage of their respective salaries, and the citizen shareholders shall receive an agreed additional increase in their dividend for that year. Maximum salaries for the respective directors and a maximum dividend for the shareholders to be fixed.

(f) The Dominion to finance the whole system including the provision of the funds for new railways, for all additions and improvements to existing lines and for rolling stock and other equipment chargeable to capital account, as may be stated to be required by the board. In the event of a difference of opinion between the board and the Minister of Railways (representing the Dominion) in respect of any of such capital account requirement, the question to be submitted to the authority referred to in Clause "g" for investigation and report—the decision of such authority to be final.

(g) The construction of a new railway not to be undertaken nor any commitment to it given until an investigation and report it regard to it have been made and the report laid on the table of the House by a competent authority—independent of politics—say, a board of three members thoroughly well qualified for the purpose.

(It might be interjected here that a similar procedure should be followed in all cases involving large expenditures or disbursements of public money on or in connection with works, such as new railways, canals, docks and harbors, dredging, important buildings, etc., and the authority above mentioned might also be utilized to investigate and report in regard to such projects. Every member of Parliament would thus have knowledge based on independent and competent authority as to what he was voting on and the public would know what their representatives in Parliament had voted for.)

(h) Rates and fares and other charges for transportation and other services not to be increased without the approval of the Dominion Board of Railway Commissioners.

Except as hereinafter specified in Clause (i) rates and fares and other charges are not to be reduced without the consent of the board until a substantial reserve guarantee fund has been provided out of net revenue (in excess of the fixed charges, bonuses to directors and extra dividends to shareholders) and the net revenue has been sufficient in three successive years to pay all such fixed charges, bonuses to directors and extra dividends to shareholders, and then only to the extent which, based on the average traffic of the said three years, shall represent a reduction in the net revenue equal to the net revenue in excess of the said fixed charges, bonuses and extra dividends.

(i) The Dominion may by Order-in-Council declare a matter (such as a reduction in transportation or other charges for services rendered or the construction of a new railway) to be one of general policy and direct the board to give effect to such policy, but in the event of the board not concurring in whole or in part in such direction, the Dominion shall reimburse annually to the whole system seventy-five per cent. of the yearly increase in expenditure or of the decrease in revenue of the whole system occasioned by the carrying out of such direction in excess of such increase or decrease as would have been occasioned by the carrying out of such direction to the extent only to which the board concurred in it.

(j) The accounts and books of the company to be continuously audited by an auditor to be appointed by the Governor-General-in-Council, who shall certify to the

balance sheet, profit and loss account and other annual statements of the company.

The Grand Trunk Company has never paid any dividend on its common stock, but it would be necessary under this proposal to guarantee a small dividend on that stock in order to secure the consent of the holders of it to the inclusion of the Grand Trunk system in this scheme. It would also be necessary, in order to avoid legal and other complications and serious delay to guarantee the interest and other fixed charges (not already guaranteed by the Dominion and Provincial Governments) of the Canadian Northern and Grand Trunk Pacific Systems.

The idea which is in mind in providing for bonuses for the chairman, vice-chairman and other members of the board and increased dividends to the citizen shareholders, in the event of certain results in net revenue being obtained, is to make it in their financial interest to efficiently administer the whole system, thus increasing the net revenue. This incentive to efficient management is an important factor in the scheme.

It would be highly desirable to have a large number of representative citizens of the Dominion interested financially and otherwise in the administration of the railways of the Dominion and through the appointment by them of four out of nine directors of the operating company to have a voice in such administration. A scheme can easily be devised by which the citizen stock in the operating company will be equitably distributed and held by all classes of the community throughout all the provinces of the Dominion and

The provision and maintenance of a substantial reserve guarantee fund is advisable to avoid possible disarrangement in the Dominion budget owing to the need of making provision therein to meet any deficit in guarantees, etc., in a year of unfavorable railway results, due, for instance, to a failure or partial failure in the harvest.

What is in mind in Clause (i) is to prevent a deadlock between the government of the day and the board in the event of the government considering it desirable in the interest of the public and the country to have effect given to some matter of general policy, which policy in whole or in part is not concurred in by the board (such as, possibly for instance, a reduction in rates). In such event, the Dominion, representing the public and the country to be benefited, should be willing to sacrifice the larger proportion of the loss in net revenue of the whole system occasioned by giving effect to such policy.

The interests of the public can be safeguarded by preserving the present Board of Railway Commissioners, in whose jurisdiction and authority, however, consequential restrictions and modifications would be necessary if effect were given to this scheme, as, for instance, in the matter of reducing rates and fares. The Board of Railway Commissioners might also be charged with the duty of seeing that the lines, equipment, etc., are maintained in a safe and efficient condition, and that the train and other services are such as the business justified.

Very large economies in operation and maintenance can be effected if the five systems herein included in this scheme are worked as one for the good of the system as a whole. The utilization of the shorter or easier and therefore cheaper routes for traffic, the taking up or temporary abandonment of useless lines or lines of little value where the public would not be appreciably affected, the ability to use all motive power and rolling stock freely on any part of the whole system, thus saving much unnecessary movement, especially of freight cars, and obtaining greater service out of such shipment, reductions in train services without appreciable disadvantages to the public by avoiding at present duplicate services, joint instead of separate stations, terminals, offices, etc., with consequent reduction in staff, concentration of work in shops and elsewhere, larger purchases and therefore lower prices of all materials and supplies, etc., etc. The savings which could be effected in these and other directions are so many and the aggregate would represent such a large amount that they might go a long way towards paying the deficit in the earlier years resulting from the operation of the Canadian Northern, Grand Trunk Pacific and Government systems.

Another advantage in combining all, or most of the railways in one system to be worked for the good of all is that the construction of competing lines would be prevented and that new lines would be so located that the least possible mileage would serve the greatest possible area or population, and that railway subsidies with their evil influences would disappear.

It may be urged as an objection to the foregoing scheme that there would be an absence of competition, but competition between railways as it has existed, has been wasteful and far from efficient in the true sense of that word. As has been mentioned, the Dominion Board of Railway Commissioners can and should be clothed with the necessary authority to safeguard the best interests of the country and its trade and of the public generally and to insure the proper maintenance and safe working of the railways and the provision of as good and efficient service of every kind as the business offering and other circumstances justify.

Under this scheme it would not be necessary to raise any large sum of money to purchase any of the railways—a great advantage in these war times.

No matter how independent a board of commissioners for the administration of State railways may be made by the legislation under which such a board is originally constituted and appointed the time will surely come, and at no distant day, when the board owing to its very independence will incur the displeasure, if not the hostility of the government or of parliament and when this occurs the independence of the board from political control or interference will surely be taken away or modified by amending legislation. In such a scheme as is here suggested, however, there would be an agreement between the Canadian Railways Company and the Dominion confirmed by legislation which could not be interfered with by the government of the day or by parliament, even if the inability to use the railways for political purposes be resented. This is an important feature of the scheme.

Eventually, perhaps before many years, lower rates for transportation and other services rendered by the railways would be possible and commercially justified under some such scheme as this than if the railways continued to be administered and operated as separate units—some of them by the State and some of them by companies—or than if combined in one great system, they are administered and managed by the State under a board of commissioners originally intended to be independent of politics.

A scheme can, it is believed, be worked out on some such lines as the foregoing under which all the important railways of Canada can be combined and worked as one great system with enormous savings in working expenses and other beneficial results, under which competition between the State and private enterprise and interference thereby with vested interests can be avoided and under which there would be the advantage of such efficient and prudent administration of our railways as that of a well-managed company.

W. F. TYE ADDRESSES OTTAWA BRANCH OF CANADIAN SOCIETY OF CIVIL ENGINEERS.

W. F. Tye, past president of the Canadian Society of Civil Engineers, and formerly chief engineer of the Canadian Pacific Railway, addressed the members of the Ottawa Branch of the Canadian Society of Civil Engineers on March 29th at a luncheon at the Chateau Laurier. "The only way in which you can get any good out of anything in this world is by work," said Mr. Tye to a large and representative audience. "The only way in which you can get any public recognition whatever is by work. If you want recognition from the public, you must work for the public. If you do not want to work for the public, you won't get recognition. If you do not take your fair share in the load of governing this country, you can't expect to get public recognition, and I do not know of any body of men in all Canada who are better fitted by their training to guide public opinion than the engineers of Canada, more especially as so many of our great public problems are engineering problems."

Mr. Tye referred to his paper on Canada's railway problems and said that his object in putting it out was simply to bring before the people of Canada the gravity of the railway situation, and that if it accomplished that purpose he would consider that he had been amply repaid for his work.

Objection was taken by Mr. Tye to the appointment of lawyers, farmers, etc., on engineering commissions, and he impressed upon his hearers that the government must appoint more Canadian engineers on commissions. He also referred to the employment of American engineers and intimated that the fault lies with the Canadian engineers in not bringing their own merits forward; in other words, in not successfully selling their own services to the government.

"I am quite sure," said Mr. Tye, "that man for man we Canadians are just as good engineers as the Americans are. There may be, of course, some particulars in which they have experience in which we as a younger country have not had experience and therefore in this respect it may be all right for the government to go there for men. But if we want our fair share in this business of advising the government, we must firmly—very nicely and politely, but firmly—tell the government that we do not propose to stand for that sort of thing. We have rights, but in this world if you want your rights you have to fight for them. You have to tell every government in power that we are just as good engineers as the Americans and we propose to have our fair share of the business that is going.

"The reason that this condition exists is that while the engineer has in private life a very good standing, and his standing is improving at all times, yet in public estimation I am not quite sure we are not going backward; that is, our standing is not as good as it used to be. In the old days, thirty or forty years ago, there were some outstanding engineers who had considerable say in the government, or things having to do with the government. I am not quite sure that the engineers nowadays have not that standing, and I say again, I think it is entirely our own fault, because we do not take part in public discussions.

"I do not think that in the parliament of Canada today there is a single engineer; there may be, but I do not know of any. I do not believe there is one in the senate. One reason, it seems to me, why we are in this condition is that we are leading what I might call lives that are entirely too self-centered. Every one of you is thinking of your own particular little job, whatever it is, whether it is work in one of the departments, or whether you are chief engineer of a railway, or working for a railway or canal or private company. You are thinking of that and giving your whole undivided attention to that and serving the private interests to the best of your ability, but you are not taking part in the public discussions. It seems to me that among all the different people in Canada the engineer by his training is the one best qualified to lead and direct public opinion. This is the engineer's age."

CONTROL OF PAVEMENT OPENINGS.*

By E. P. Goodrich,
Consulting Engineer, New York City.

The best way to treat a pavement opening is not to make it. In order to accomplish this end, several things have been worked out to advantage:

(a) Place sub-surface structures under sidewalks and grass strips. This is the German method, and has been demonstrated more efficient economically than the construction of pipe galleries.

(b) Whenever a pavement is to be replaced over a large area, all sub-surface structures should be renewed, or at least carefully examined and repaired; all house connections similarly treated, and the ground restored to as nearly virgin condition as possible under the new pavement. To secure this result, corporations owning sub-surface structures should be notified in ample time to permit them to do this work. Householders should be notified to examine their structures, signs should be posted upon the street stating that the street is to be repaved, and sub-surface at structures must be carefully examined and prepared, and the fact further advertised by newspapers and handbills, if necessary. This practice was followed in the Borough of Manhattan for several years, but some of the corporations found that it was costing so much that they refused to continue the practice. The number of cuts in the new pavements increased perceptibly. Some effort should be made to force the corporations and property owners to make all needed repairs to their structures while the pavement is open. This may mean a revision of the franchise law, and it may mean a change of ordinance.

Except in cases of emergency, permits to open a newly laid pavement should be rigidly refused. The period of such refusal might extend to several years. Hartford, Conn., is said to allow no openings in new pavements until after action by the city council during a period of 10 years. Taking for granted that some cuts must be made, it is obviously essential to know where the sub-surface structures are actually located so that it will not be necessary (as is now often the case) that the corporation or the plumber will have to explore, making three or four openings in order to discover a leak.

This can be accomplished through an adequately financed and administered Bureau of Sub-Surface Structures. Starts toward such a bureau have been made in each of the boroughs in New York City, but their development has not yet been carried so far as to make the work of that department of very much importance except in Brooklyn.

*Abstracted from a paper read before the Citizens' Street Traffic Committee of Greater New York.

THE TRANSPORTATION OF MATERIALS.*

By George Hogarth,
Provincial Engineer of Highways, Ontario.

IN the construction of highways where a surface of a more or less permanent character is to be prepared the moving of the construction materials to the site of the work deserves the closest attention of those in charge. This applies to sand clay road construction; also to the building of gravel and macadam roads and pavements of concrete or bituminous materials, since in each of these types of construction a great deal of hauling has to be done. For the gravel and macadam roads, gravel and crushed stone must be moved in fairly large quantities; for the bituminous pavements, crushed stone and bitumen are required, while for the concrete pavement, sand, crushed stone and cement are essential.

In laying out the work of road-building the sand or gravel pits or stone quarries from which the materials will be secured are probably located so that wagons can be loaded at the plant and despatched directly to the road. At times material may be secured from distant sources of supply which will require that the railways deliver the cars at stations convenient to the road. A proper selection of unloading points will facilitate construction, and due regard should be given to the choice of roads leading away from the railway stations in order that serious damage to the surface of such roads may be avoided.

An important point in the handling of all materials is to see that the loading and unloading of all wagons is carried out with the least possible delay. At the loading end, bins may be made use of, since by that means a wagon is easily and rapidly loaded. This avoids delays to the teams and a better showing will be made in the daily tonnage hauled. The manner of unloading the wagons also calls for some care, and the type of box used will to a great extent determine what can be done at that end of the work. There are two types of wagons used for hauling, the slat-bottom wagon and the bottom-dump wagon. The bottom-dump wagon seems to be in general use to-day, as it has been shown to be the handiest for quick unloading.

Where materials are moved by power, such as on industrial railways or with tractors or motor trucks, it is necessary that well-equipped yards be provided to facilitate rapid unloading and handling. Large storage bins will be required so that on arrival of empty wagons an ample quantity of material can be quickly loaded by gravity. If bins cannot be provided, then mechanical means should be obtained for loading and a crane installed. A large saving can usually be effected by careful attention to the quick loading of the wagons.

No matter how small or how large the work in hand may be, the superintendent should endeavor to keep an accurate check on the work done in order to arrive at the cost of the hauling. Cost data is very useful in preparing estimates and in comparing the work of different gangs or outfits and every opportunity should be taken to arrive at the cost of the various parts of the work. Each superintendent will find that his charges for doing the same kind of work will probably vary from those of his neighbor doing exactly the same work, and the investigation pursued in finding out the reason for any large differences will usually result in certain reforms or betterments being made. By all means keep cost data, as it is the only way in which the work can be proved to be efficient.

Hauling by Teams.—For the greater percentage of road construction to be carried on for some years there is no doubt but that we must depend upon teams for the hauling of all material. Teams furnish a slow method of transportation and have a number of advantages and disadvantages. In some cases it might be found advisable for the county to own a few teams in order to set the working pace and always have teams available when wanted. When purchasing a team buy only the best horses and see that they are properly looked after. While a county might own a few teams, it is usually advisable, for economic reasons, to hire locally whatever other teams may be required. That is one advantage of teams, they can be obtained almost everywhere in sufficient numbers to do almost any ordinary job, and where a job is of small proportions it can be done most economically with teams hired at the site. Teams do their best work during summer when the temperature is moderate and when the roads are dry and in good condition for hauling. When hot weather arrives teams will be found to slow down in pace and to tire more readily, so that rest periods must be provided. That is a disadvantage possessed by teams and is a weakness to which mechanical transport is not subject.

Typical Loading Outfit on County Road Work.

The cost of hauling materials by teams will be affected by the state of the weather, by the kind of roads over which teaming is carried on, by the nature of the country, whether hilly or level, by the capacity of the team for work, and by the rate per day paid for teams. In view of the number of important factors entering into the cost of hauling by teams it will be seen that costs may differ considerably in various parts of the country. On ordinary roads it will be found that a team will average about 20 miles per day for round trips, or, say, 10 miles per day with a load. Over easy grades a team should be able to move from 1½ to 2½ tons at a load, or an average of, say, two tons hauled 10 miles at a cost of $5 per day. The cost of hauling by teams is, therefore, on an average about 25 cents per ton mile.

Mechanical Haulage.—Where a large system of roads is mapped out for construction and the building of these roads may extend over a term of years the question of hauling by mechanical means should be examined into and an estimate of cost made of using such machinery. The types of mechanical haulage available to-

*Paper read before the Third Annual Conference on Road Construction, Toronto, March 27th to 30th, 1917.

day are as follows: (1) Road rollers. (2) Steam tractors. (3) Motor trucks. (4) Industrial railways.

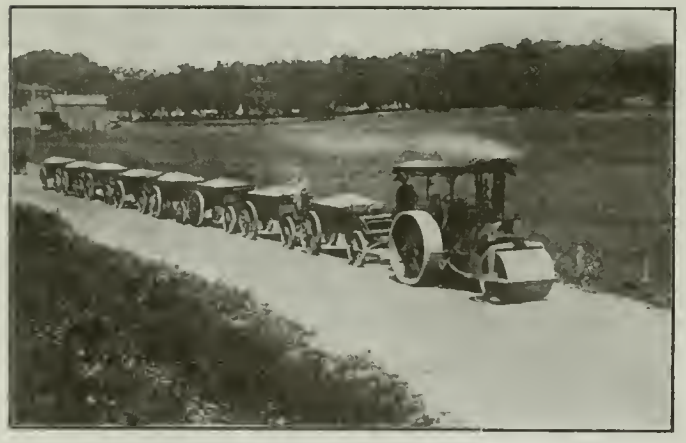
In estimating on using any of these means of hauling a number of vital points enter into the calculations. One of the most essential details to the estimate is the first cost of the equipment. In order to arrive at the cost of moving the unit, one ton, one mile, or the ton-mile,

Wagons Hitched to Steam Tractor.

as it is commonly known, it will be necessary to consider the annual cost of the equipment, which will be the total of the interest on the investment, depreciation per year, cost of repairs, operating charges and the superintendence. The total of that sum divided by the number of ton-miles hauled per annum will show the cost per ton-mile.

Road rollers are in some cases used for hauling, but because of slow speed they are not economical. However, in an emergency they may be of considerable use.

Steam tractors capable of hauling a train of five or six dump-cars have been of use in road construction. The first cost of one outfit, consisting of one tractor and five cars, is about $3,700, and the annual charge is in the neighborhood of $4,100. In working 150 days per year the machine should move on an average about 30,000 tons one mile, so that the average cost of hauling by this means would be from, say, 7 to 10 cents per ton-mile. These figures are based on 6 per cent. interest on investment, a depreciation of 15 per cent. per year,



Train of Wagons Hitched to Road Roller.

repair bills of 5 per cent. per annum, operating charges $6.75 per day, and superintendence 5 per cent. The steam tractor is usually easily kept in a good condition of repair, is of simple construction, with strong details, and may be operated by almost any intelligent mechanic. The figure of 7 to 10 cents per ton-mile is calculated upon operating the engine for 150 days per year, and on any ordinary job it is possible to obtain efficient operation and costs as low as those quoted.

This low cost of hauling is made possible by the use of probably five or six trailers, each of which may have a capacity up to four yards or more. Such a train will be in charge of two men, and 25 or 30 tons would be hauled per trip. On short hauls, with good roads and no hills, a very low rate for hauling by this means would be obtained.

Motor Truck Haulage.—Hauling by means of motor trucks has come into general use in the cities during the last few years, and to-day nearly all tradespeople and warehouses deliver and transport their goods by motor truck. In view of the popularity enjoyed by the motor truck for this class of work it is advisable that we look closely into its methods of operation and costs for building roads in the country.

One advantage enjoyed by the truck in the city is that everywhere good pavements are found, and a low-powered truck is able to move a large load satisfactorily under all weather conditions and practically for 300 days per year. Such pavements are ideal for truck operation.

It is well to point to this fact, and also as a comparison to call attention to the general state of country roads during spring, autumn and winter months of the year, when impassable conditions exist. For hauling by

Hauling Wagons by Motor Truck.

truck in the country it is believed that 150 working days per year will be about the maximum that truck operation is possible. The capacity of truck to purchase is important. Practically every size from 1 to 6 tons is manufactured and sold to-day. The heavier truck is seen at its best when operating over good roads, but for general hauling purposes the lighter truck will give better satisfaction, and experience indicates that the 3 or 3½-ton truck is the largest capacity that should be considered. The military authorities favor 1½ and 3-ton trucks, and these sizes have given satisfaction over what are described as horrible roads. Contractors on road work in the States claim that a 5-ton truck will usually spend a good deal of time extricating itself from ruts or broken bridges or culverts, and during wet weather pulling itself out of the ditch. They have had trouble with the heavy truck, and to-day they believe the 3 or 3½-ton truck is the best to use. For one reason or another the heavy truck is frequently delayed on the road. Delays to such equipment decrease the efficiency greatly, as in order to get proper results a truck must be operated continuously.

In operating a truck on road construction it is often impossible to choose turning-places, and in some cases turns must be made in very close quarters. For that reason it is well to consider the wheel base of the truck being purchased. A long wheel base may prove awkward.

With a truck having a wheel base of 124 inches it is possible to turn around on a 12-foot road with a sand shoulder.

In road construction one 3½-ton truck will usually replace six teams, and with that data and some experience in the operation of trucks it is possible to estimate the cost of motor truck hauling. It will usually be found that on road construction the cost of tire renewals is fairly high and will amount to 5 to 5½ cents per mile of run.

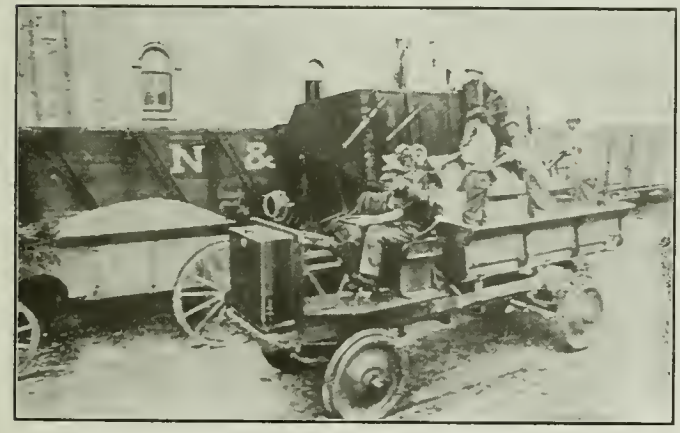
An estimate of hauling by 3-ton motor truck, based on 150 days' operation per year, is as follows:—

Cost of truck, $6,000.

Annual Cost.

Interest on investment, 6 per cent. on $6,000.		$ 360.00
Depreciation per year, 20 per cent.		1,200.00
Repairs		200.00
Operating charges—		
Chauffeur, six months at $80..	$ 480.00	
Gas and oil, $4 per day.....	600.00	
Tires	375.00	
		1,455.00
Superintendence, 5 per cent. of $3,215.....		160.75
Total		$3,375.75

In one season's operation under favorable conditions the truck will haul about 20,000 ton-miles at a cost of $3,375.75, or 17 cents per ton-mile.



Loading From Railroad Car to Motor Truck.

Such a truck may be good for a life of more than five years, and in some cases ten years is the economical life of well-built trucks, so that the cost per ton-mile for moving materials by motor truck will probably be from 12 to 15 cents per ton-mile.

Haulage by Industrial Railway.—Narrow-gauge industrial railways have been used for years in the operation of coal mines, and our steam railways of to-day are a compromise between the narrow and broad gauge of 50 years ago.

Industrial railways are adapted to the haulage of large quantities of material required in important undertakings, and their use may be particularly advantageous for road purposes under certain conditions. Points in their favor are that they can run over soft ground wherever a track two feet wide can be laid, they do not rut or tear up the road over which they operate, and wet weather has little or no effect on them.

Light rails having a weight of about 20 pounds per yard are used, and these are fastened to steel ties by bolts and clips, so that two men can handle a section of track. The cars used are usually steel, and of "V" shape, having a capacity of about two tons, and arranged so as to dump to either side of the track. The cars weigh about 1,000 pounds, and, depending on the grades, 16 to 30 loaded cars may be hauled in a train. By this means 32 to 60 tons of material are moved to the destination at one trip and at a speed of from 5 to 8 miles per hour. As a long-haul outfit the industrial railway is to be recommended, but the investment necessary to provide the equipment is many times the cost of any other method of hauling.

The outfit will usually require a length of track from 6 to 18 miles, and the total first cost of track, locomotives, cars and accessories will be anywhere from $35,000 to $60,000.

With such a large investment there is a heavy charge for interest and depreciation, while at the same time overhead expenses, operating expenses and incidentals may be heavy. The cost per ton-mile for moving material by this means may be anywhere from 17 to 25 cents per ton-mile.

Such a railway on a large work will frequently prove economical, but in order to do so efficient operation is required and a heavy expenditure for yards and quick-loading apparatus must be incurred.

STEEL COMPANY OF CANADA.

The satisfactory report of the Steel Company of Canada shows that, after deducting charges for repairs, maintenance and improvements and providing for war tax for the years 1915 and 1916, the net profits were $5,021,391. These were dealt with in the following manner: Interest on bonds, $525,819; deferred dividends on preferred stock for two quarters of 1915, $227,370; dividends on preferred stock for the year 1916, $454,741; distribution on ordinary shares for the year 1916, $460,000; reserve for bond sinking fund, $165,454; reserve for depreciation, $601,624; transferred to betterment and replacement reserve, $953,526; credited to profit and loss account, $1,632,855: total, $5,021,391. The amount now standing to the credit of profit and loss is $4,647,497.

The company's balance sheet shows assets aggregating $38,178,921, current assets amount to $12,385,492, current liabilities are shown as $2,896,719, and the reserves total $3,116,104.

The allotment to the bond sinking fund was $88,500 in 1915 and $165,454 in 1916. In 1913 $56,738 was set aside for dismantling Sunnyside works, and in 1911 the sum of $39,000 for underwriting loans, and in 1914 $104,475 for a similar purpose. During the past year dividends on common stock took $460,000 and $953,526 was allotted to a betterment and replacement reserve.

Mr. R. Hobson, president, in his remarks, drew attention to the difficulties which Canadian industrial concerns have to surmount. He said the company's plants were fully occupied, but like all other companies, the Steel Company were hampered by the shortage of labor, and the difficulty of getting delivery of raw materials, supplies, etc., from firms who have also experienced labor shortage, and by reason of the congestion on the railways.

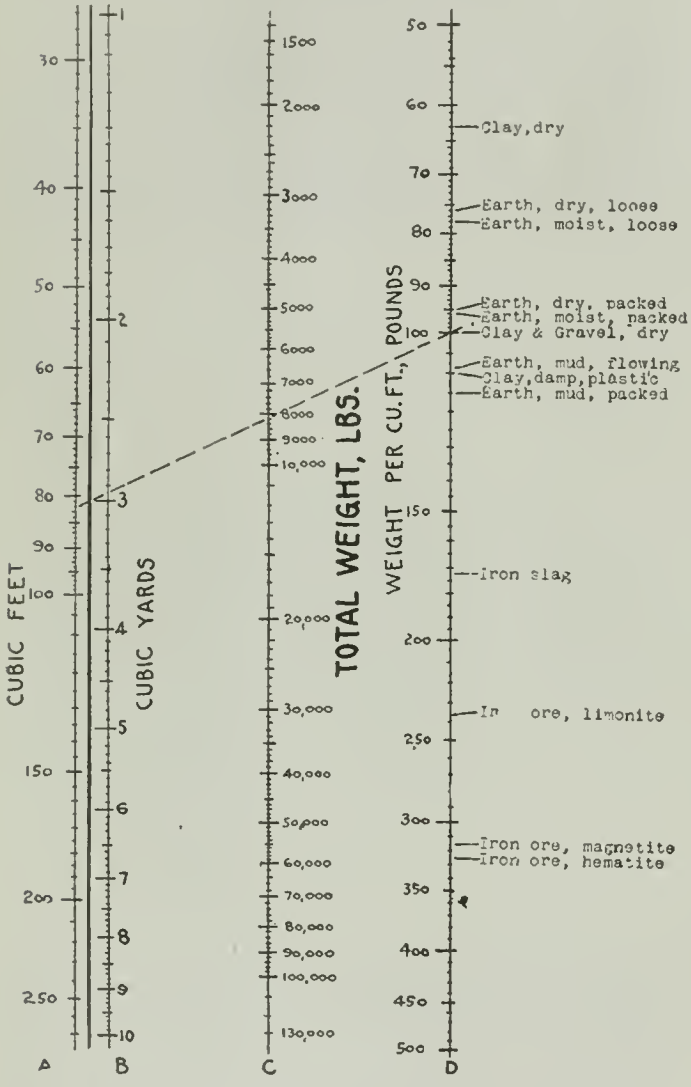
The President of Bolivia has been authorized by Congress to undertake, under the direct supervision of the State, the construction of the Uyuni-Tupuiza Railway between Atocha and Tupiza. The Atocha-Tupiza section is all that remains to be constructed of the line which eventually will connect La Paz with Buenos Aires. It is believed that this through Bolivian route will become an important rival of the Panama Canal, since it will offer quicker and more direct transportation from Europe to the west coast of South America.

A HANDY CHART FOR WEIGHING EXCAVATED MATERIALS.

Simply lay a straightedge across this chart once and the weight of any excavated material may be found by reading the middle column, column C.

For example: What is the weight of three yards of dry clay and gravel?

Find the 3 in column B and from its point on the heavy black line between columns A and B run a line to the 100 (column D), which is the weight of dry clay



and gravel per cubic foot, and the result—8,100 pounds—is found in column C. (See the dotted line on this chart.)

Whether the volume of material is given in cubic feet or in yards makes no difference, either is worked in the same way—always find the corresponding point on the heavy black line first and then connect with the weight per cubic foot.

In case the volume is 30 cubic yards instead of 3, all you have to do is to add another cipher to the result and the weight is 81,000 pounds instead of 8,100 pounds. This chart is, therefore, capable of taking care of any yardage, no matter how great or small.

Even though you are excavating a material that is not listed here, the chart is usable, provided you know the weight of the material per cubic foot. Thus dry, loose sand and gravel weighs from 90 to 105 pounds per cubic foot, and, therefore, cannot be listed on this chart with definiteness, but it is a simple matter for the engineer in charge of the excavation to determine the average weight of the particular material he is excavating and then apply the chart. Dry, packed sand and gravel weighs from 100 to 120 pounds per cubic foot. Riprap weighs from 80 to 105 pounds per cubic foot. depending upon fineness or largeness, and whether it is sandstone, limestone or shale.

This chart, therefore, serves a double purpose. It gives the weights of the most common excavated materials per cubic foot and it is ready at any time for weight computations.—"Excavating Engineer."

McGILL UNIVERSITY AWARDS DEGREES.

Honorary degree of LL.D. was recently awarded to seven scientists and educationalists by McGill University. Those honored were Sir John Kennedy, of Montreal, Dr. W. H. Ellis of the University of Toronto, John J. Carty of New York, Hon. F. Carter-Cotton, chancellor of the University of British Columbia, Prof. Jas. Cappon, dean of Faculty of Arts of Queen's University, H. S. Pritchet, president of the Carnegie Foundation for the Advancement of Teaching, and Sir Cecil Arthur Spring-Rice, G.C.M.G., British Ambassador to the United States.

Following is an abstract of the reasons assigned by the University for the awarding of these degrees:—

"To Sir John Kennedy because of his eminence as a civil engineer, of the fidelity with which he has always upheld the highest ideals of the engineering profession, and of his long and distinguished services in developing the port of Montreal and the transportation routes of Canada, services which His Majesty has graciously recognized by conferring upon him the honor of knighthood.

"To John J. Carty in consideration of his high standing as an engineer, for his work in connection with the development and successful operation of wireless telephony, and for his energetic support of pure scientific research as an aid to industry.

"To Dr. W. H. Ellis on the ground of his eminent services in developing scientific and industrial chemistry in Canada, his literary attainments, his life-long devotion to scientific education in connection with the School of Science, of which he was one of the founders at the University of Toronto, and his valuable services and investigations in medico-legal chemistry and toxicology, in which field he stands pre-eminent in Canada.

"To Prof. Jas. Cappon on the ground of his long and honorable record as a member of the teaching staff of Queen's University, and of the distinguished quality of his literary work.

"To Hon. F. Carter-Cotton on the ground of his support of and interest in higher education of the Province of British Columbia, and the zeal he showed for many years in the development of the McGill University College of British Columbia."

Building permits for the month of February, 1917, for 38 cities of Canada amounted to $1,503,939, as compared with $662,135 in the corresponding month in 1916, an increase of approximately 125 per cent. The greatest gain was in Eastern Canada, the figures being $1,365,497, as against $553,406. The figures for the four Western provinces total $138,442, as against $108,729.

DEMANDS MADE UPON SEWER PIPES.*

THE committee is of the opinion that before final conclusions may be reached regarding the specifications and tests for clay and cement sewer pipes there must be substantial agreement as to the demands made upon them under ordinary service conditions. With these demands established it will then be possible to consider the necessary properties of the several materials and to recommend practical tests which should be applied in order to determine the compliance with the demands.

In order to state the general demands upon sewer pipes the committee decided to consider separately those which relate to strength, durability and serviceability.

Conditions Affecting Strength of Sewer Pipe.—The static forces applied to the outside of a pipe are those resulting from the loads or quiescent pressures acting upon it. These loads or pressures are made up of the weight of the body of material resting vertically over the pipe, either with its weight in entirety or reduced by the cohesion with the adjoining material, and transmitted as components of forces deviating from the vertical, and acting outside of the body resting vertically over the pipe.

The trench filling is usually kept free from large stones and consists of clay, loam, gravel, sand or of their mixture. A compacting of this material is produced by ramming or watering of the trenches, which increases the weight per cubic foot and thereby the pressure upon the pipes. The maximum weights which cause vertical pressure upon the pipes, and which must be sustained by them, are therefore determined by knowing the weight per cubic foot of the compacted superincumbent material, its depth in feet and the weight of any possible load that may rest on the surface above the trench.

If the material above the pipe were a liquid without cohesion we could obtain the exact pressure upon the pipe in the manner above indicated. Where the cohesion of the material is great, as in rock,—in other words, if the pipe is laid beneath a roof of rock,—there would be no pressure at all upon the pipe.

In the usual trench filling, we therefore have all possible degrees of cohesion varying from a puddled filling which may act as a liquid, and transmit the full weight of the material upon the pipe, to a material such as hard-pan or rock which sustains itself and transmits no weight to the pipe.

In practice, therefore, we can expect great differences in the pressures of the materials over pipes, which fact explains the differences of opinion prevailing as to the proper weight allowance upon pipes and of the formulas suggested (Frühling, Barbour, Marston and others) therefor to determine such pressures. Table I. gives the weights of various trench-filling materials for different heights of fill.

The material on both sides of the mass resting vertically over the pipe,—unless it is hard-pan or rock,—may by sliding press upon the pipe in directions other than vertical. In other words, the pressure will act by its components. One set of these components will always be horizontal and if the pressure is alike on both sides of the trench, the two opposing components will completely balance each other. The other set of components will be vertical and their action is resisted by the friction against the original trench wall on each side of the pipe. Where the original components act upon the pipe itself they will again be divided into components; one set will act at right angles to the exterior surface thereof,—in other words, press towards the centre of the pipe. They will, therefore, press horizontally at the horizontal diameter of a circular pipe; they will press downwards above it and upwards below it. The other set will act within the shell of the pipe and parallel to the surface.

Dynamic Forces.—The dynamic forces are those which may result from bodies moving either quietly or suddenly, and in such manner that the resultant force, or its components, can act directly upon the body of the pipe. Such dynamic forces are caused by a heavy moving load passing over the trench in which a pipe is laid. They may be the effect of a body of earth sliding or settling in or near the trench; or they may be the impact of a body upon the pipe, as that of a falling stone or of the pipe itself falling upon the ground.

The maximum static equivalent of live loads which may pass over a sewer trench should be 300 lbs. per square foot of surface. This load may be increased by 87 per cent. for impact. Bodies falling upon the pipe which cause greater stress than those produced by the drop-weight test need not be considered as a condition to be guarded against by greater strength of pipe.

Internal forces which are imposed upon sewer pipes under conditions of use are hydrostatic pressure and water hammer.

Hydrostatic Pressure.—Hydrostatic pressure, as usually expressed, is the weight in pounds of a column of water of 1 square inch section, having a height which extends from the point where the pressure is to be measured, up to the highest elevation of any connecting water standing outside of the pipe. Table II. gives the hydrostatic interior pressures per square inch at various depths to which sewer pipes may be exposed in practice.

Table I.—Weight in Pounds of Trench-Filling Materials.

Height of Fill, ft.	Loose Top Soil	Top Soil Clay	Dry Sand	Damp Sand	Top Soil, Tamped	Clay and Sand, Tamped	Sand, Tamped	Sandy Loam, Tamped
2 ...	140	160	194	182	226	218	230	192
4 ...	280	320	388	364	452	436	460	384
6 ...	420	480	582	546	678	654	690	576
8 ...	560	640	776	728	904	872	920	768
10 ...	700	800	970	910	1,130	1,090	1,150	960
12 ...	840	960	1,164	1,092	1,356	1,308	1,380	1,152
14 ...	980	1,120	1,358	1,274	1,582	1,526	1,610	1,344
16 ...	1,120	1,280	1,552	1,456	1,808	1,744	1,840	1,536
18 ...	1,260	1,440	1,746	1,638	2,034	1,962	2,070	1,728
20 ...	1,400	1,600	1,940	1,820	2,260	2,180	2,300	1,920

Table II.—Hydrostatic Interior Pressures.

Depth, ft.	Pressure, lb. per sq. in.	Depth, ft.	Pressure, lb. per sq. in.
2	0.868	16	6.94
4	1.73	18	7.81
6	2.50	20	8.68
8	3.47	22	9.54
10	4.34	24	10.41
12	5.20	26	11.06
14	6.07		

Tests made of the resistance to bursting pressure of well-made pipe show it to be so much greater than the sewer pipe is subjected to, that the demands for this purpose may be neglected. This is the more true, since the

*Abstracted from report of Committee appointed by the American Society for Testing Materials.

hydrostatic pressure will usually receive less resistance in the joints than in the pipes themselves.

Water Hammer.—A water hammer in a pipe is caused by the shock against the barrel of a pipe of a sudden stoppage of the flow of water within it. This stoppage may result from a sudden closing of a valve or a sudden clogging by floating or suspended material, or by a break of the pipe and caving in of the trench.

The maximum force of a water hammer tending to break the pipe depends on the mass of water in motion and its velocity.

Properties of Raw Materials.—The clays or shales used for the manufacture of sewer pipes should possess those physical and chemical properties which will secure strong, tough vitrification at moderate heat, and absence of excessive warping, shrinking, fire cracks and other objectionable defects in the finished product.

The committee will present more complete and detailed statements with respect to these required physical and chemical properties when the necessary data are supplied by those most familiar with these properties.

Adulterants, such as fine grindings from well-burned clay, may be used to reduce shrinkage, etc., provided the strength or durability of the finished pipe is not thereby diminished.

The water used in tempering the clays or shales should be free from salts, alkali, acid, mineral and gaseous impurities in quantities such as have been found in practice to render the water unsuitable for this special purpose.

The cement used for cement-concrete pipe should be Portland cement, whose physical and chemical properties comply with the proposed American Specifications and Methods of Tests for Portland Cement (Serial Designation.....) of the American Society for Testing Materials.

The sand used should consist of grains from hard, tough, durable rock, and be free from soft, decayed, and friable material. It should be free from lumps of clay, loam or other foreign material. It should not contain more than 2.5 per cent. by weight of finely divided clay, loam or other suspended matter. The grains should have rough, unpolished surfaces, and be well graded in size from the finest to the coarsest. Not more than 8 per cent. by weight, including suspended matter, should pass the No. 100 sieve, and not more than 60 per cent. should pass the No. 16 sieve. None of the grains should be retained on the No. 4 sieve.

Mortar in the proportions of 1:3 by weight when tested at the age of 28 days, should develop a tensile strength at least equal to the strength of a similar mortar made of the same cement and standard Ottawa sand tested at the same age.

The broken stone used should be irregular pieces or crushed trap or other hard, tough, durable rock in graded sizes. None of the pieces should be less than ¼ inch in minimum diameter, and none larger in maximum diameter than three-tenths of the thickness of the sewer pipe in which it is to be used. The stone should be washed if necessary to remove dust, dirt or other foreign substances.

Gravel of the same degree of hardness, toughness and durability, and of the sizes specified for stone, may be used in place thereof if free from dust, dirt and other foreign substances.

The stone and sand, or the gravel and sand, should each be of such graded sizes that, when mixed with cement in definite proportions, and with the required amount of water, they will produce a mass of maximum weight and density.

The water used for the concrete should be fresh (not salt) water, free from excessive turbidity, sulphur, carbonic acid and other mineral or organic substances detrimental to its use for this special purpose.

Waterproofing compounds, if used, should possess such physical and chemical properties as are necessary to render the concrete impervious to water without adversely affecting its strength or durability.

Manufactured Pipe.—The proportions of ingredients of cement-concrete pipe shall be at least equal to that of first-class gravel concrete of proportions, 1 part of first-class Portland cement, to 1 part of clean, coarse graded sand, to 1 or 2 parts pebbles.

A pipe which is very porous will allow passage in and out of water or sewage through its shell. This passage or slow percolation of water is, from a sanitary point of view, of little moment in all but rare cases and then it requires special consideration. The porosity of the shell is, however, of importance with reference to its bearing upon the strength of the pipe, when this is subject to either external or internal forces. As affecting the strength of a pipe the degree of its allowable porosity will depend upon the character of the material and the process of manufacture of the pipe. The stronger the final product, the less objectionable will be a greater degree of porosity. In the case of cement-concrete pipe we must, however, consider the effect of percolation of acid or alkali water which tends to disintegrate the hard carbonate of lime. Experience has shown that the greater the porosity the quicker is the disintegration. It has also shown that for normal sewage the effect is negligible if the material is uniformly compact and the percolation extremely slight.

It is, therefore, the opinion of the committee that the actual effect of porosity upon the strength of a pipe should be determined by more experiment and that, therefore, tests should be made so as to indicate the most economical relations between strength and porosity for the principal classes of material and manufacture now in the market. The results of such tests should be published for each make, indicating the actual porosity for tested strengths of pipe. When subjected to an internal pressure of 10 lbs. per square inch, sewer pipe shall show no percolation.

The quality of toughness in the material of sewer pipes, which is the opposite of brittleness, is important, as it affects their being readily broken by handling before they are laid, or broken by internal forces, such as water hammer, after they are laid.

The toughness of pipe is best ascertained and measured by the impact of a body having a fixed weight and drop distance, when striking the centre of a pipe fixed in a horizontal position. The degree of toughness as thus measured should be sufficient to prevent rupture under the above-stated ordinary conditions, which demands a somewhat arbitrary standard depending more or less on local practice. The committee recommends a drop test as follows:—

When supported on a dry sand bed 2 ins. deep, all pipe shall withstand, without cracking, the impact from two blows of a cast-iron ball weighing 8 lbs. falling 18 ins. Spurs shall resist, without fracture, the impact from two blows of such a ball falling 6 ins. and striking on the extreme end of the hub of the spur.

Vitrification of Clay Pipe.—The vitrification of clay pipe should be carried as far beyond its first indication as practicable, because it increases the strength of the pipe. But it should not be carried to a degree that would lower the desired degree of toughness.

The standard for vitrification must, therefore, also be arbitrary, and it depends not only upon the degree of desirable toughness, but also upon the properties of the raw materials used.

Defects in clay pipe are fire cracks, blisters and laminations. These imperfections should be avoided so far as practicable, because to some extent they reduce the strength of the pipe. The reduction is found particularly when the fire cracks in a pipe are abundant and extend far into the shell. It is also found when the material is laminated and particularly when the breaking shows splitting between layers of material. Blisters, unless very deep, do not affect the strength, but rather the serviceability, of a pipe.

The permissible limits of these defects should, therefore, also be arbitrary standards, depending upon the purposes for which the pipes are to be used.

Where high strength is required, fire cracks should be rare. Where they occur they should never extend into the shell more than 1/8 in., irrespective of the test for strength. Where laminations occur in pipes such should cause rejection, unless the tests for strength are quite satisfactory for the proposed use of the pipes.

Hair cracks are caused by shrinkage of the cement during the process of drying and setting, and when exposed to a material drop in temperature soon after setting.

The permissible limits must be arbitrary and should depend upon the purposes for which the pipes are to be used. Such cracks unquestionably lower the strength of the pipe. They should therefore be rare, and never destroy the continuity of the material of a section of the shell more than 1 sq. in., and such depreciated cross-sections should not be less than 6 ins. apart. Such individual hair cracks should not exceed 0.1 mm. in width, and should not be more than 2 ins. long, and not penetrate the shell more than 1/8 in.

Thickness of Shell.—The thickness of the shell of a pipe, to resist external and internal forces, strictly speaking, should vary with the qualities of the original material from which the pipe is made and with the treatment during its manufacture. A thinner shell of tougher and denser material may resist greater pressure than a thicker pipe which is less tough and compact.

The committee therefore believes it would be unsafe to specify a definite relation between diameter of pipe and the thickness of shell, and that it must be left to the guarantee of the manufacturer that the pipe which he offers for sale shall be, in all cases, of sufficient thickness to withstand the standard crushing loads specified.

The committee favors the establishment of a minimum thickness for each size of sewer pipe and submits, as a result of all the available information, Table III. for consideration.

The committee is of the opinion that there may be a demand at times, for cheaper pipes with thinner shells than those above specified, but it believes that in such cases the understanding should be clear that such pipe is not classified as standard pipe.

There may also be a demand at times, for pipe which must safely sustain a greater weight than the above standard. In such exceptional cases, means should be provided for securing the necessary increase of strength, either by embedding standard pipes in concrete or by surrounding them with concrete of sufficient thickness to resist the greater weight.

Ends of Pipe.—The ends of pipe should be so shaped as to permit the making of a joint which, in strength, approaches the strength of the pipes in resistance to shear, bending moment and crushing stresses, and which is also sufficiently impervious to the passage of water. In vitreous materials it is impracticable to obtain that accuracy of dimensions which will permit close contact at all points of the pipe ends, and for this reason the strength of jointed pipes in these materials is to be secured by means of the jointing material. For this purpose it is best to have space for ample jointing material such as is furnished by extra wide and deep sockets. The outside surface of the spigot end and the inside surface of the hub or socket end should be unglazed, or else these surfaces should be scored with V-shaped depressions to provide for a bond with the jointing material.

Where the ends of pipes can be finished to true surfaces, as with cement-concrete pipes, it is practicable to shape these ends as male and female bevels which can be brought into close contact throughout. Such a joint, when covered with a suitable layer of cement mortar to increase the rigidity and to prevent the passage of water, is quite as satisfactory as the hub-and-spigot type with extra wide and deep sockets, although it does not appear to have any particular advantage over the latter except possibly some economy in handling and laying. The ends of cement-concrete pipe furnish good bonding surfaces for the jointing materials and, therefore, do not require to be scored. Table IV. gives minimum values for depth of socket and annular space for various diameters of pipe.

Table III.—Minimum Thickness of Shell.

Diameter of Pipe, in.	Minimum Thickness of Shell, in. Vitrified Clay Pipe	Cement-Concrete Pipe
6	5/8	3/4
8	3/4	7/8
10	7/8	1
12	1	1 1/4
15	1 1/4	1 1/2
18	1 1/2	1 3/4
20	1 2/3	2
22	1 5/6	2 1/4
24	2	2 1/2
27	2 1/4	...
30	2 1/2	...
33	2 5/8	...
36	2 3/4	...
42	3 1/2	...

No pipe should be used until pipes cast in the same factory of equal age are strong enough to meet the specified crushing test.

Recommendations with respect to the making of joints have been furnished in the proposed Tentative Recommended Practice for the Laying of Sewer Pipe, as heretofore reported by the committee and published in the 1915 Year-Book.

Gasket and mortar joints, in vitrified pipe sewers, shall be made in the following manner:—

A closely twisted hemp or oakum gasket of suitable diameter, in no case less than 3/4 in., and in one piece of sufficient length to pass around the pipe and lap at the top, shall be solidly rammed into the annular space between the pipes with a suitable caulking tool. Before being placed, the gasket shall be saturated with neat cement grout. The remainder of the space shall then be completely filled with plastic mortar mixed 1:1 and the joint wiped inside and finished to a smooth bevel outside.

Joints of sanitary pipe sewers below the normal water table shall be made with a compound approved by the chief engineer. The compound shall preferably have a bituminous base, shall adhere firmly to the glazed surfaces of the pipes, shall melt and run freely at a temperature as low as 250° F. and when set shall be sufficiently elastic to permit of a slight movement of the pipes without injury to the joints or breaking the adhesion of the compound to the pipes. The compound shall not deteriorate when submerged in fresh or salt water or normal domestic sewage; it shall show no deterioration of any kind when immersed for a period of five days in a 1-per-cent. solution of hydrochloric acid or a 5-per-cent solution of caustic potash.

Table IV.—Minimum Depths of Socket and Annular Spaces.

Diameter of Pipe, in.	Depth of Socket, in.	Annular Space, in.	Diameter of Pipe, in.	Depth of Socket, in.	Annular Space, in.
6	2½	⅝	22	3¾	⅝
8	2¾	⅝	24	4	⅝
10	2¾	⅝	27	4	¾
12	3	⅝	30	4	¾
15	3	⅝	33	5	1¼
18	3¼	⅝	36	5	1¼
20	3½	⅝	42	5	1¼

After a joint is properly caulked, a suitable runner shall be placed and the compound, heated to a temperature of approximately 400° F., shall be poured into it in such a manner that the annular space shall be completely filled to within ½ in. of the outer rim of the bell of the pipe.

Unless otherwise permitted, at least four finished joints shall be left exposed for inspection throughout the working day, and the necessary staging for the protection of the exposed sewers and for the handling of excavated material shall be provided. The joints on the inside of all pipe sewers larger than 15 ins. in diameter, shall be carefully filled with mortar and wiped smooth and flush with the surface of the pipe.

TO ACT ON NICKEL REPORT

That nickel refineries can be successfully operated in Ontario, and that a tax should be made on the net profits of the producing companies, are important suggestions contained in the report of the Ontario Nickel Commission, made after eighteen months' research.

The legislation to be based on the commission's report will provide for taxes on all Ontario mines the annual profits of which exceed $10,000, which are to be raised from 3 per cent. per annum to 5 per cent. per annum upon the annual profits in excess of $10,000 and up to $5,000,000. On all annual profits over $5,000,000 and up to $10,000,000, the tax will be 6 per cent. per annum; on all annual profits over $10,000,000 and up to $15,000,000 the annual tax will be 7 per cent.; and on the annual profits in excess of $15,000,000 a percentage increasing with each additional $5,000,000 in the same proportion as in the case of the second and third five million dollars.

On nickel and nickel-copper mines the new taxation is effective as from the 1st January, 1915.

SLAG AS AN AGGREGATE FOR CONCRETE.

INVESTIGATIONS and tests made to determine the availability of slag as an aggregate for concrete were described by Mr. Sanford E. Thompson, Consulting Engineer, Boston, Mass., in a paper presented at the thirteenth annual convention of the American Concrete Institute. The investigation by Mr. Thompson covered the following:—

The use of slag for plain and for reinforced concrete.

The relative value of slag versus gravel for building construction.

The relative characteristics of slag made from different processes.

The relative value of the same slag under different conditions of age, size and porosity.

The strength of slag concrete, with the permissible proportions and stresses to adopt.

The durability of slag concrete.

To properly treat these various questions, several series of tests were undertaken. The data derived from these tests and from a study of previous investigations are summarized in the paper as follows:—

The strength of concrete made with slag, such as is obtainable commercially in eastern and northern Ohio, was on the average about 50 per cent. higher at the age of 28 days than gravel concrete made with first-class materials.

Using the same proportions by volume as for gravel concrete, about 15 per cent. more cement on the average was required per cubic yard for slag concrete than for gravel concrete of the same proportions.

No authentic cases of deterioration of slag concrete made with Portland cement or of rusting of steel embedded in such concrete have been discovered.

Porous slag produced a concrete of substantially the same strength at 28 days as dense slag. At later ages, the dense slag is probably stronger.

Slag made by different processes and under different conditions showed no marked difference in strength and other characteristics.

An extremely hard, dense, acid slag did not produce a concrete of greater strength than porous, basic slag on a 28-day test.

The weight of the slag concrete tested averaged about 6 per cent. lighter than an average gravel concrete. On the other hand, very dense acid slag concrete was heavier than gravel concrete.

Granulated slag sand produced a mortar of inferior tensile strength on short-time tests.

Crushed slag screenings produced a mortar appreciably higher in strength than standard sand mortar.

No tests of watertightness of slag concrete were made in this series nor of protection of metal. Tests by other authorities and examinations of structures of slag concrete and tests made with concrete of other aggregates show that when properly laid the steel is protected from rust, even although the aggregate is porous.

Tests thus far made of permeability of slag concrete are insufficient to determine its availability for thin, watertight work, such as tanks.

The weathering qualities of slag concrete are indicated as satisfactory by examination of structures which have been built for a number of years, but further experimental investigations along these lines with different types of slag are needed before the conclusions as to its use can be considered final.

CANADA'S WORK IN FOREST RESEARCH.*

MANY of the investigations now under way at the Forest Products Laboratories are intended only to cover the immediate problem before us, but others are designed to proceed until a knowledge of the basic principles of the subject is obtained. Such, we consider, is the most real purpose of our institution. The wood-using industries of our country are not of such size as to warrant their establishing individual laboratories of this kind, and if the Forest Products Laboratories of Canada can furnish to these industries scientifically accurate information concerning their materials and products and the manufacture of these products, then we of the laboratories will consider that we have not only earned our salaries, but that we have done our little bit to promote the industrial greatness of Canada.

A very brief mention of a few of the investigations which are now being carried on will suffice to show what we are attempting at present, though we are considerably handicapped by the absence of some of the best of our staff who are at the front and the impossibility of getting other suitable men at this time.

Some of the leading investigations now on hand are as follows:—

A comparative study of the mechanical strength and physical properties of all Canadian woods. Tests are made on a large number of small, clear specimens cut in the same way from several trees of each species selected in the forest by Forestry Branch experts. These tests are being made on the same system as a similar series of tests under way at the United States Forest Products Laboratory, so that our results will be directly comparable with theirs, and when both series are complete the data will cover all the North American woods.

A study of the comparative value and characteristics of mine timbers available for use in the coal mines of Nova Scotia. This includes strength tests and a study of the decay of such timbers, both in the mines and in storage. Already considerable improvement has been made in storage conditions so as to greatly decrease the loss from rotting in the piles.

A study of the fundamental factors involved in the drying of wood and phenomena related to change of moisture content, such as shrinkage, hygroscopicity, migration of moisture in the wood, heat conductivity, etc.

A study of methods looking for the utilization of waste sulphite liquor. About 600,000 tons of wood per year is consumed in the manufacture of sulphite pulp in Canada, and approximately one-half of that amount of organic material is thrown to waste in the liquor. The problem of finding a use for this material is a very complicated one, and, although a great deal of research has been done on the subject by various English, German and American chemists, only results of moderate value have been obtained. At present the work of these laboratories is confined to the compilation of all available information in connection with this subject, leaving experimental work to be done later on.

A study of the fundamental factors involved in the beating of paper pulp. This beating process is a very important one in the manufacture of paper, particularly in the case of finer grades, and is one concerning which very little is known. A full understanding of the reactions involves a very complete knowledge of the colloidal characteristics of cellulose, thus leading to very involved questions of physical chemistry. This research is one of the type mentioned as being of so complicated a nature as to necessarily extend over several years, but is one which we are peculiarly well situated to attempt.

A study having for its object the discovery of a commercially feasible process of creosoting Jack pine and Eastern hemlock for use as railway ties.

An investigation as to the feasibility of chipping, drying and baling pulpwood for shipment and a determination of the value of chipped and dried wood as compared with round wood. There is a possibility that there may be a saving in freight effected which will make possible the utilization of forest areas which are now going to waste.

An investigation of the chemical composition of wood, particularly of those woods which may be of use for paper pulp. This work involves the testing and standardization of methods of analysis and the examination of the composition of several important species, both in the green condition and after different degrees of seasoning.

An investigation of the possibility of treating prairie grown woods so as to make possible their use as fence posts.

A study of the oils produced by the destructive distillation of wood, both resinous and hardwood, with reference to their use in ore flotation.

A study of the relative durabilities of Canadian woods when exposed to various kinds of wood-destroying fungi.

A study of the fibre dimensions of Canadian woods. This is particularly important to the paper industry, but is also of value in other work as well as being of considerable scientific interest.

A study of the sulphite cooking process and the factors involved in cooking various species of wood for pulp. It is hoped that a thorough study of the process from a scientific point of view combined with practical experience will point out ways in which the process can be improved.

The investigations mentioned do not include any but the outstanding problems. Besides these there is submitted to the Laboratories a continuous flow of minor questions which the laboratory equipment enables us to answer quite readily. Questions regarding the identification of wood from samples, for instance, are answered daily for people all over the country at no cost to them.

*Brief excerpts from an address by W. B. Campbell, Assistant Superintendent, Forest Products Laboratories, McGill University, Montreal. Delivered before the annual meeting of the Canadian Forestry Association.

According to the statistical report of the Quebec Provincial Mines Branch, of the Department of Colonization, Mines and Fisheries, of which the Honorable Honore Mercier is Minister, the total value of the mineral production of the Province for 1916 is only one-half of 1 per cent. less than in 1913, the figures of which still constitute the highest record. The report also shows that the total value of the mineral production of the province for the year ending December 21, 1916, amounted to $13,070,566, an increase of 14 per cent. as compared with the previous year. The main item in the list is asbestos, which figures for a value of $5,182,905. Asbestos mines here produce about 90 per cent. of the world's supply. Other items which show very substantial increases are lead and zinc ores, chromite, magnesite, mica and molybdenite

LETTERS TO THE EDITOR

Municipal Consulting Engineers.

Sir,—In connection with your postscript of the 28th ult. re an editorial in your March 15th issue entitled "Municipal Consulting Engineers," we had read this editorial and were much surprised to learn its contents.

Our firm considered answering the editorial several times, but we did not do so, partly owing to the fact that Mr. Godfrey's deduced statements contained therein were so evidently erroneous that we did not think them worthy of consideration, and partly owing to the fact that we had been rather busy of late, and could not take time to discuss them.

We may say that in our experience in the West we have very seldom exceeded our estimates. In one town in which we were engaged as consulting engineers the town informed our firm that they were prepared to expend $200,000 on municipal improvements, and we were accordingly requested to prepare their improvements to accommodate this amount. When the contracts were awarded they totalled to $198,000.

In another town in which we were engaged as engineers we gave them an estimate of $130,000 on the proposed works, and the contracts were awarded at $125,000. In no case in our experience have we exceeded our estimates more than a very small percentage of the actual amount expended, and as you will know, conditions often arise which could not be provided against when making the estimates, but creep in during the progress of the work.

Of late years, or since the money market became so stringent, and particularly since war broke out, many of the municipalities in the West have been compelled to sell their debentures at a discount, the by-law having already been prepared and voted on before the war started; some of them sold as low as 20 per cent. discount. This, you can see, would create quite a deficit in, say, a $200,000 by-law. Also, in almost every case while the work is progressing the councils decide on further improvements or additions which makes it necessary for them to prepare a new by-law. The people often receive the impression that the amount of the new by-law should have been included in the original estimate, and it has been observed that when the actual cost exceeds the original estimate by a few thousand dollars, that some councillors, we must say, have made capital of this small amount as an excuse for having to go to the people again, rather than explain to them that they had approved of certain additions, as well as selling their debentures below par.

We were very pleased to learn that in your answer to Mr. Godfrey you did not consider that his statements should be taken seriously, and we feel certain that your remarks will be appreciated by many qualified engineers throughout the Dominion.

We are also disposed to consider that other consulting engineers acting throughout the West will have had much the same experience as that cited above, and in our opinion it would be quite preposterous that any reputable firm of consulting engineers should deliberately underestimate on any proposed improvements for the purpose of having the people carry a particular by-law, which they knew would not furnish the required amount to complete the work.

MURPHY & UNDERWOOD,
Per J. E. UNDERWOOD.

Saskatoon, Sask., April 2nd, 1917.

Sulphur in Road Oils.

Sir,—The clause regarding the sulphur and acid content of road oils, referred to in your editorial of the 29th inst., and the opinions of chemists on this clause as contained in the same article, once more raises the question of the desirability of more co-operation between engineers and chemists. Much has been wirtten in the past on this subject with evidently but little avail.

So long as the chemists are called upon to make examinations of materials used for engineering purposes it is only reasonable to expect that they should be consulted when the specifications for these materials are prepared, but at present this course is the exception rather than the rule. It occurs all too frequently that, owing to the nature of the specification, the value of the analysis is largely nullified and no redress can be had from the contractor. Specifications are too often made up in a patchwork manner from other specifications and put together without considering whether the parts are compatible with one another. As an example of this I might mention one specification that I came across some time ago. This was for asphalt, and one clause stated that Trinidad and other asphalts could be tendered upon, whilst another clause excluded Trinidad by specifying that the asphalt must contain at least 90 per cent. of bitumen, soluble in carbon bisulphide.

Some specifications merely state that the material shall be of the best quality, a statement that is delightfully vague and open to many (mis)interpretations. Others go to the other extreme, and contain a number of clauses defining with great minuteness the physical and chemical attributes of the material required. More often than not, no attempt is made to ascertain if the material is in accordance with the standards set forth, with the result that the contractor quickly develops contempt for these clauses and ultimately ignores them.

The obvious remedy for these difficulties is closer co-operation between engineers and chemists, and a step which, I think, is in the right direction was made last year by the Society of Chemical Industry by the appointment of a committee to study and recommend standard methods of analysis. When this matter was discussed in Montreal I was successful in having a resolution adopted asking for the co-operation of societies engaged in kindred work, and amongst those named was the Society of Civil Engineers. Standard methods of analysis are largely chemical matters, but when the material examined is used in engineering practice the engineers are vitally interested. This is especially so when chemical and physical constants are referred to in contracts and standard methods are specified. As an example of this I would cite the contract for the new filtration plant in Toronto. This, I believe, states that certain efficiencies are to be guaranteed when the tests are made in accordance with the standard methods of the American Public Health Association. The contract was let in 1914, and since that date the methods of analysis have changed very materially in some respects, and if the present standard methods were used it is possible that they might show very different results. It is, therefore, in the interest of engineers to endeavor to keep methods of analysis as stable as possible and to prevent yearly changes that are often evanescent and futile.

JOSEPH RACE,
City Bacteriologist and Chemist.

Ottawa, March 31st, 1917.

Editorial

IS THE HYDRO ARBITRARY?

Sir William Mackenzie and Sir Adam Beck have been providing the Toronto daily press with reams of free copy of late. Sir William has responded directly to few, if any, attacks during the past several years. Withdrawing into his knightly armor, he has suffered the swords to beat upon the metal, telling himself that they were merely lath-sticks and harmless. But Sir Adam found a hole in the armor a couple of weeks ago—a hole, by the way, which Sir Adam bored months previously by means of anticipatory legislation. Sir Adam's thrust was strong, and it aroused Sir William and his associates to denial, denunciation and dentiloquy.

The Hydro's head had accused the Electrical Development Co. of stealing water from the Niagara River. As president of that company, Sir William Mackenzie denied the charge, which, he said, is based upon the Hydro's own arbitrary interpretation of the company's agreement with the Victoria Park Commission.

Is it a fact that the Hydro is arbitrary? We believe that it is, but we also believe that the Hydro, as the trustee of the water resources of the province, must be and should be arbitrary in respect to allotments of water from the Niagara River.

The well-known treaty of 1910 allows Canada 36,000 sec.-ft. at Niagara. It is a point of national honor that not a drop more than that be taken. To stay rigidly within that limit and yet supply the enormous demand for power throughout Southern Ontario, it is imperative that the existing power companies be restrained from wasting water. Additional water passed through any of the three existing Canadian plants means waste. It would be developed at 136 to 180 ft. head, whereas the Hydro would develop it in their new Queenston plant at over 300 ft. head, and every second-foot used by any of the present companies means a second-foot less available for development at Queenston.

The Electrical Development Co. was organized under an agreement executed in 1903 with the Victoria Park Commission, stipulating that the company would be permitted to divert sufficient water from the river to develop 125,000 electrical horse-power. While this agreement was under negotiation it was represented to the province by the company's counsel that the operating head would not be less than 140 ft. The company also agreed not to instal turbines and electrical equipment for the generation of more than 125,000 electrical h.p., although each company at the Falls actually installed one spare unit. The Electrical Development Co. has eleven machines, each supposed to be 12,500 e.h.p. capacity, and at least one is supposed to be idle at all times. It appears that the Hydro is of the opinion that these machines are largely in excess of 12,500 e.h.p. and that the plant as a whole is being operated to the fullest extent of its installed capacity. Whether or not this is true, investigation under the terms of the Water Powers Regulation Act will no doubt reveal. The Victoria Park Commission, in its annual report just issued, accuses the Electrical Development Co. of developing 136,000 electrical h.p., and says that it has reached between 140,000 and 150,000 h.p. on peak load.

As the 1910 treaty assigned the water in terms of cubic feet per second, the evident intention of the Hydro is to define the rights of the three companies uniformly in the same terms. If the rights of the Electrical Development Company are properly stated above in the matter of capacity and operating head, the amount of water necessary to give effect to these rights, assuming an overall plant efficiency of 81.5%, would be about 9,650 sec.-ft.

The Province of Ontario, through the Hydro as its agent, has the right to require any reasonable efficiency from any water power plant in Ontario under the terms of the Water Powers Regulation Act, an appeal to the Lieutenant-Governor-in-Council being allowed to the water power owner. If extensive alterations or reconstruction are necessary to the carrying out of the province's efficiency requirements, the Lieutenant-Governor-in-Council fixes the amount of the compensation, if any, to be allowed to the company for such work. The idea appears to be not the infliction of hardships on operating companies, but the conservation of the power resources of the province.

The whole trend of the argument between Sir Adam and Sir William, and of the Hydro legislation introduced during the past couple of years, and particularly during the last session, shows that it is the Hydro's ultimate intention to buy one, two or all three of the Canadian power companies at Niagara in order to be able to develop more water under the 300 ft. head at Queenston. The whole 36,000 sec.-ft., if developed at Queenston, would mean over a million h.p. for Ontario, compared with about 405,000 electrical h.p. now permissibly developed by the three Canadian private companies. The handwriting on the wall must have been apparent to Sir William for some years past.

ECONOMICS AND THE ENGINEER.

The subject of economics in its modern aspect may be said to be the application of reason to industry; that is, as time advances the economics of industry represent a larger proportion of the alleged science.

It is well to bear in mind the fact that the science so limited is far from exact and is yet only groping toward the light. Its theorems and axioms are susceptible to controversion and argument. One man, breaking almost every commandment, may yet survive in business to give pause to the acceptation of academic and accepted theory. It is never safe to dogmatize unless you know, and not so very safe then.

It is, however, certain that in its real aspect the knowledge of economic matters cannot be neglected; its foundations are in the very human cement, common or garden sense. What most surprises the engineer brought into contact with it as a subject for the first time is that he has practised its precepts without subscribing to its formulæ in ignorance that any principles existed. Another surprising thing is that what the theoretical student finds most difficult to comprehend is as clear as daylight to the intelligent engineer.

If the nomenclature in which every specialist loves to enshroud his subject be reduced to common terms the definitions re-worded and the arguments made clear by specific example, the subject so stripped of its mystery is readily grasped.

If economic argument is developed by specific instance, then every engineer can from experience find the material from which to argue. A knowledge of essential

economic fact combined with intuitive appraisement of human nature, serves to supplement and add greatly to technical ability.

The engineer is, in short, the true economist; if he were not, there would exist no engineering science at all. Unless the product of his inventive genius resulted in economy of time, saving in actual cost, or added to public convenience its decay would be inevitable if it had ever developed at all. On the grounds cited, it does exist and expand, hence those in contact therewith are already economists if not economic experts, whether they are conscious of the fact or not.

While all this is true, a great many technical men fail to realize that the subject is worth their attention. While it is generally considered a commercial subject of a business nature the engineer who takes trouble to read a few treatises on the subject finds his interest quickened and his powers improved.

The weakness of most technical training is want of commercial realization. The study of economics supplies in the main this deficiency to the ultimate advantage of the practical man when called upon to face larger issues. As a useful corrective to exclusive concentration upon distinctly technical matters its value can scarcely be overstated and the engineer is already prepared and usually proves an apt pupil. Short of a grasp of essential facts concerning exchange and finance and other related phenomina of trade and commerce, the highly trained technical man finds that superior positions are filled exclusively from the commercial side. It is realized that this is unjust but technical capacity is of value only in technical matters and there is a technique of business whose name is economics.

C.P.R. SCHOLARSHIPS AT McGILL UNIVERSITY.

George Bury, vice-president, Canadian Pacific Railway, has issued the following circular: "Three free scholarships, covering four years tuition in chemistry, civil, mechanical or electrical engineering at McGill University, are offered, subject to competitive examination, to apprentices and other employees enrolled on the company's permanent staff and under 21 years of age, and to minor sons of employees. The competitive examination, which will be the regular entrance matriculation examination provided for in the University's annual calendar, will be held at the University, Montreal, and at other centres throughout Canada, in June. The candidates making the highest average and complying with the requirements of admission will be awarded the scholarships and have the option of taking any of the above courses. Scholarship will be renewed from year to year, to cover a period not exceeding four years, if, at the close of each session, the holder thereof is entitled, under the rules, to full standing in the next higher year. In case a scholarship holder finds it necessary to interrupt his course for a year or more, notice must be given at the close of the session to the company and to the Dean of the Faculty of Applied Science of the University, in order that the scholarship may be open to other applicants. In order to establish prior claim to the next available scholarship, notice of the students' intended return must be given to the company and to the Dean not later than January 1 preceding the opening of the session in which such scholarship will be available. Applications for certificates entitling eligible persons to enter the competition should be addressed to C. H. Buell, Staff Registrar and Secretary, McGill University, Montreal.

PERSONAL.

P. J. VENOIT has been appointed Minister of Public Works of New Brunswick.

F. ROBERTS, town electrician of Pincher Creek, Alta., has resigned in order to enlist for overseas service.

T. T. AUSTIN has been appointed manager of the waterworks department, Belleville, Ont., in succession to J. W. Evans.

C. J. HUNT, who until recently was chief contract engineer to Bruce Peebles & Company, Limited, Edinburgh, has been appointed chief engineer to the company.

J. RUSSELL ELLIS, acting city engineer of Regina, Sask., has resigned. D. A. R. McCannell, formerly assistant engineer, will succeed him, and R. W. Allen will succeed Mr. McCannell.

C. B. HUYCK, formerly with Mussens Limited, of Montreal, who enlisted as a private with the 6th Company Divisional Engineers, which was recruited from Queen's University, Kingston, and who has been in France for two years, has just recently been granted his commission.

WILLIAM TANSLEY, formerly assistant superintendent of the London, Ont., division of the C.P.R., has been appointed superintendent of the company at Montreal. He will be succeeded by E. WILLIAMS, superintendent of the Brockville Junction Division, who in turn will be succeeded by H. J. HUMPHREY, who has been acting superintendent of the Laurentide division with headquarters at Montreal.

H. S. PHILLIPS, A.M.Can.Soc.C.E., of the engineering staff of the Canadian Nitro Products Co., has received a commission as a lieutenant in the Tunnelling Section of the Canadian Engineers. Mr. Phillips was formerly assistant engineer in the sewer section of the Department of Works, Toronto, and was loaned by that department to Prof. Phelps to assist in the preparation of the latter's report on "Pollution of Boundary Waters," recently presented to the International Joint Commission.

OBITUARY.

JOSEPH GEROUX, a Quebec contractor, died on April 4th at the age of 52.

ALFRED BATHO, a Toronto contractor, died recently at the age of 70 years.

HUGH RUSSEL, president of Hugh Russel & Sons, Limited, iron and steel merchants, of Montreal, died recently at his home at the age of 73 years.

CORRECTION.

In our issue of March 15th, 1917, there appeared an article on the "Don Incinerator," Toronto. It was stated that "The plant is equipped with three high-temperature "Sterling" furnaces of modern design, which have been installed by the Canadian Griscom-Russell Company, Limited. There are three furnaces of four units each. Each furnace has a grate area of 25 square feet," etc. The foregoing should read, "There are three furnaces of four cells each. Each cell has a grate area of 25 square feet."

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

FOURTH ANNUAL DOMINION GOOD ROADS CONGRESS

REPORT OF SESSIONS HELD IN OTTAWA LAST WEEK—CONGRESS OPENED BY GOVERNOR-GENERAL, ACTING PREMIER SIR GEORGE FOSTER AND SIR WILFRID LAURIER—STATESMEN PROMISE GOVERNMENT'S HELP IN THE GOOD ROADS MOVEMENT

MANY men prominent in road building in Canada and the United States, gathered in Ottawa last week for the Fourth Canadian and International Good Roads Congress and Exhibition.

The exhibits were attractively arranged on the main floor of the Horticultural Building, Lansdowne Exhibition Park, while the meetings were held in a hall which seated about 300, on the second floor of the same building.

The exhibitors were the Canada Cement Co., Canadian Fairbanks-Morse Co., *The Canadian Engineer*, Commission of Conservation, General Supply Co., Imperial Oil Co., T. S. Kirby & Co., Ottawa Valley Motor Car Association, McLaughlin Automobile Co, Paterson Mfg. Co., Sawyer-Massey Co., Trussed Concrete Steel Co., U.S. Steel Products Co. and Warren Bituminous Paving Co.

The features of the exhibits were the very complete outfit of "Case" and "Wettlaufer" road-making machinery shown by the Canadian Fairbanks-Morse Co., Limited, who had no less than twelve large machines of various kinds on view; the pictures and plans exhibited by the town-planning department of the Commission of Conservation; the model bituminous street shown by the Imperial Oil Co.; the power flusher exhibited by the General Supply Co.; the model road sections built for the Province of Ontario; the illuminated photographs by the Paterson Mfg. Co.; the section of concrete roadway built jointly by the Trussed Concrete Steel Co., the Canada Cement Co. and the U.S. Steel Products Co., showing the use of Canada cement, of U.S. steel mesh reinforcement, and of Truscon curb bars, road mesh and armor plates; and the sections of pavements, experiments showing result of filling the voids, and magnified road sections shown by the Warren Bituminous Paving Co.

The Governor-General Opens Congress.

The congress was called to order Tuesday afternoon, April 10th, by the president of the Dominion Good Roads Association, J. Duchastel de Montrouge, city engineer of Outremont, P.Q., who introduced His Excellency the Duke of Devonshire, Governor-General of Canada.

"I have not had very much opportunity to see many roads in Canada," said the Duke of Devonshire, "but those I have seen have filled me with admiration,—not for the roads, but for the skill of the driver and the strength of the vehicle." He looked forward to the time when Canada would be well supplied with good roads as a result of the policy that was being adopted by the provinces from coast to coast.

Reference was made by the Governor-General to the fact that he had presided over a committee, for the discussion of road questions, which had been formed from both houses of the British parliament. He had always been greatly interested in roads and a strong advocate for the extension of good roads in England. He called attention to the permanent beneficial effect which good roads had had upon England, and how they had helped to solve the housing problems of the larger cities. With the improvement of the streets and roads he thought that the trackless trolley would no doubt appear in this country, and he laid stress on the importance of giving due consideration to this method of transportation in the future.

Sir George Foster Represents the Government.

Sir George E. Foster, who is acting as premier during Sir Robert Borden's visit to England, attended on behalf of the Dominion Government. Sir George reviewed the history of the good roads movement from the haphazard methods of half a century ago to the specialized construction of the present day, declaring that the future history of the country would be bound up in its road development. "Good roads are a reflection of the nation's character and the progress it has attained," said Sir George. There was no need to convince him, as an old politician, of the importance of good roads. Sir George gave his assurance that the government would further the cause of good roads to the best of its ability.

To show that there is no politics in the good roads movement, Sir Wilfrid Laurier sat with Sir George Foster on the platform, and followed Sir George with an earnest address advocating better roads. When he was a boy, said Sir Wilfrid, the only road master in Quebec province was the sun. When the sun shone, there were good roads; when it disappeared for the winter, there were no roads; and when it disappeared behind the clouds in the summer on account of rain, there were practically no roads. The people are only beginning to realize that the wealth of the country lies in its good roads.

That good roads throughout the Dominion would have considerable bearing on the economic, industrial and social problems of the country was the opinion expressed by His Lordship Bishop Roper, of Ottawa. He referred to the old Roman roads and the highway by the Euphrates and the Black Sea to Constantinople, and said that roads had always formed a great part in military and international history.

Mayor Harold Fisher, of Ottawa, officially welcomed the delegates to his city, outlining what had been accomplished in Ottawa in the last five years in road-making. He said that more permanent roadways had been laid in and around Ottawa in the last five years than in all previous time in the city's history.

W. A. McLean, C.E., Deputy Minister of Highways of the Province of Ontario, referred to the gratification that it gives to good roads enthusiasts to know that every province in the Dominion has created special departments to deal with the questions incidental to construction of public highways.

S. L. Squire, Hon. President of the Ontario Good Roads Association, expressed the hope that the federal government would take a tangible interest, and not only a passing interest, in the work of the Roads Congress. "I welcome you to Ontario," said Mr. Squire, "to a province first in population; first in agriculture; first in manufacturing; first in wealth; and first in good roads possibilities, but unfortunately not first in good roads progress. We hope soon, however, to lead the Province of Quebec instead of being second to her as now."

A. Dion, president of the Ottawa Valley Motor Car Association, said that the association had been the projectors and pioneers of the Ottawa-Prescott Highway proposition which will link Ottawa with the highways of New York State and with the inevitable Toronto-Montreal Highway. He hoped for the early construction of the Ottawa-Prescott Highway.

Ben Michaud, Deputy Minister of Roads of the Province of Quebec, referred to the complete accord in the Province of Quebec between the ratepayers and the government in connection with good roads policies. "At the beginning," said Mr. Michaud, "a trial had been made with some county councils by giving them aid to buy stone-crushers. Then another attempt was made with local municipalities, helping them to purchase road graders. The crusher was left idle in a neighboring field and in one instance the road grader was the subject of a boisterous meeting at which a resolution was passed prohibiting the use of the implement.

How the Movement Grew in Quebec.

"We set our men to work to find out what was the matter, and why, since we were not Greeks, our presents were refused. We soon realized the truth of the old French saying to the effect that you cannot get anything unless you pay for it. We granted certain subsidies and obtained good results, but we saw that it would be a slow affair if we did not do more.

"The trend of opinion showed a general desire to have good roads and the government was anxious to give to the province the much-needed improvement. The only question to be settled was of the necessary funds. The government decided to borrow millions and to furnish the ratepayer with the money required to pay the cost of construction. It is realized that the construction of good roads is just as important as the construction of all kinds of public works, not excepting railroads. The idea was that the time had come to put good roads on a proper footing and to invest in their construction all the money available, provided that it would not interfere with sound administration.

"The government asked from the municipalities a contribution of $1,000 a mile towards provincial roads and this contribution was readily granted. As regards local roads, the government offered to pay 50 per cent. of the amount expended on macadam or gravel roads. Then the government offered all the money necessary for road construction at two and then at three per cent. interest without sinking fund. The dollars have not ceased to pour in and with such a continuity that in five years joint action of the people and of the government has given to the province over 300 miles of trunk roads, nearly 2,000 miles of improved roads, and has done away to a large extent with statute labor and has created a new spirit which will no longer suffer trails to be called roads."

Dominion Good Roads Annual Meeting.

The annual meeting of the Dominion Good Roads Association was held at Chateau Laurier Tuesday evening and it was decided to incorporate the association. Temporary by-laws were adopted and application to parliament will be made for a Dominion charter. This will place the association upon a more business-like basis and will mean a more equitable distribution of the support of the movement. Instead of the expenses of the congress being met almost entirely by the manufacturers who take space in the exhibition, the expenses of the propaganda work of the association will now be met by regular annual dues from members all over Canada. There will probably be three classes of membership, with fees ranging from $1 to $100 per annum, similar to the scheme adopted by the American Highway Association.

Wednesday's Business Sessions.

The three days' business sessions of the congress opened Wednesday morning, April 11th. Paul D. Sargent, chief engineer of the State Highway Commission of Maine, was on the programme for the first paper, but unfortunately Mr. Sargent was unable to be present and his place was taken by Jas. H. MacDonald, of New Haven, Conn. Mr. MacDonald was for many years State Highway Commissioner of Connecticut, and is now a consulting paving engineer.

He told of the small beginning of the road movement in his native state, which movement had grown to great proportions, six and a half million dollars now being the appropriation in Connecticut for this work, and his state has previously spent sixty-eight million dollars in constructing highways. Forty states in the union have been committed to a permanent good roads policy.

"Of the 200,000 miles of roadway in the United States, half that mileage will have to be overhauled and redressed," said Mr. MacDonald. "Drainage and foundation are the two necessities of good roads. Broadly speaking, the surface would almost take care of itself if the road were properly drained and had a proper foundation."

George Hogarth, chief engineer of the Ontario Public Highways Department, presented a paper on "Drainage and Foundations." In the discussion which followed, emphasis was laid on the difficulty of building roads across swamps. Mr. MacDonald spoke highly of the English rubble drain and the Telford base, which he had never known to fail.

In the afternoon W. A. McLean gave an address on the highway laws of Ontario, emphasizing the importance of preparation being made to provide public works for the employment of the thousands of men who will return from France.

"Township councils in the earlier history of Ontario," said Mr. McLean, "depended largely on statute labor for road improvement. At the present time townships in Ontario are spending annually over $1,400,000 in cash, and 1,100,000 days in statute labor, having a total estimated value of $2,500,000 annually. The mileage of roads assumed by a county is usually from 12 to 18 per cent. of the total mileage of the county."

Replying to a question by Mr. Michaud, Mr. McLean agreed that the Provincial Highway Act in Ontario is coercive to a certain extent, but that in fact it works out harmoniously, the province and the municipality agreeing as to the wisdom of building a road.

W. L. Squire expressed himself as being in favor of autocratic legislation in connection with location, standardization and assessment of cost of roads.

C. A. Mullen, of Montreal, questioned whether it was not advisable to use concrete foundations more extensively for highways, and Col. Sohier agreed that it is a good

thing where possible. Mr. Jarman, of Westmount, spoke of the tar-sand-grout roads, and Prof. Crandall, of the Barrett Co., commented on the fact that the tar and sand mixed method was invented in 1835 and then was seemingly lost until it was rediscovered by Mr. Brodie, of Liverpool, in 1900.

"Bituminous Roads and Pavements" was the title of Col. W. D. Sohier's paper. Col. Sohier is chairman of the Massachusetts Highway Commission. An abstract of his paper appears on page 333 of this issue.

T. Harry Jones, city engineer of Brantford, Ont., delivered a paper on "Cement Concrete Roads and Pavements," abstract of which is published on page 338 of this issue.

Good Speeches at the Banquet.

The annual dinner of the Dominion Good Roads Association was held Wednesday evening at Chateau Laurier. Col. Sohier, State Highway Commissioner of Massachusetts, ex-Commissioner MacDonald of Connecticut, and Sir Geo. Foster, made the principal speeches of the evening. Mr. MacDonald, who delivered an excellent address, witty and stirring in patriotism, touched but lightly upon good roads problems, but Col. Sohier's speech bristled with valuable facts and definite instances of the increased values that have accrued to the rural districts of Massachusetts through the building of good roads. The facts that he related were really startling, and showed the very great benefit of an adequate system of highways. His speech was an inspiration to road-makers and engineers generally.

Sir George Foster called attention to the fact that the benefits of good roads are not all monetary and material benefits, but that good roads are upon a higher plane, and are chiefly useful in the human uplift which results from them.

Hon. W. G. Mitchell, treasurer of Quebec Province, said that the $20,000,000 set aside by the provincial government for aid to good roads is insufficient to meet the demands. The farmer has merely to be shown where his interests are benefited, and he takes hold of the road proposition vigorously.

Mr. Mitchell said that there are 1,175 rural municipalities in Quebec with 30,000 miles of roadways, and there are towns with another 2,000 miles, making 32,000 miles of highway to maintain, in addition to numerous colonization roads. All told, there are 45,000 miles of roadways in the Province of Quebec, while the population is but about 2,000,000, and the revenue only nine or ten million dollars.

Sir Sam Hughes considered that improved highways are more important than railways because they reach a greater area of agricultural industry. He looks forward to a system whereby the federal government will provide a main trunk road across the continent, the provinces providing the subsidiary highways.

More Papers Discussed on Thursday.

Jas. H. MacDonald opened Thursday's session with a talk on the construction and maintenance of gravel and macadam roads.

A. Fraser, engineer of the Roads Department of the Province of Quebec, read a paper on "The Correction of Alignments and Grades in Existing Highways."

The paper on "Highway Bridges and Culverts," by W. G. Yorston, Assistant Road Commissioner of the Province of Nova Scotia, appears on page 331 of this issue.

D. T. Black, town engineer of Welland, explained the various methods for laying brick pavements. His paper aroused much discussion among the delegates.

W. H. Connell, chief of the Bureau of Highways, Philadelphia, gave an illustrated talk on "Granite Block Pavements," showing interesting slides. "Many streets in Philadelphia have been laid with these blocks, which, from the standpoint of durability, give very good service under heavy traffic if properly laid," said Mr. Connell.

L. Reinecke, of the Department of Mines, Ottawa, delivered a paper on "Methods Employed for Making Road Materials Surveys. "The Geological Survey," said Mr. Reinecke, "has made records of the rock formations in many parts of the Dominion, and samples from each source of supply have been investigated and recorded. In taking the census of Canada's stone supply, the surveyors have even included field stone fences, so that these could be used in case of shortage of supply."

R. B. Morley, general manager of the Ontario Safety League, delivered an address on "Safety on the Public Highway," explaining what his league has done toward making the roadways safe for both pedestrians and drivers.

Canadian Automobile Association Meeting.

The annual meeting of the Canadian Automobile Association was held Thursday evening at Chateau Laurier. W. D. Edenburn, of Detroit, delivered an illustrated lecture on the Indiana-Pacific-Transcontinental tour, which helped to locate the Lincoln Highway. He incidentally showed some pictures of the present condition of the Ottawa-Prescott Highway, showing how necessary is the proposed improvement of this road.

W. A. McLean declared that the Ottawa-Prescott Highway is simply a matter of time and will surely be improved in the near future. He defended the present roads of Ontario, declaring that at least 40 per cent. of them are well-surfaced, serviceable roads and, though not of the best, they are capable of enduring for several years. Prophesying that gradually the main centres of Ontario and Quebec would be linked up by permanent highways, intersected with a network of town and county roads, he declared that the time was not far distant when the dreams of the good roads promoters would be an accomplished fact.

Closing Sessions on Friday.

Wimund Huber, assistant engineer of the Ontario Public Highways Department, opened the last day's sessions with a paper on "Modern Road Machinery, Its Selection, Use and Care."

"Road Organization," a paper by Geo. S. Henry, M.P.P., Ontario, was extensively discussed by S. L. Squire, of Waterford, Ont., R. S. Henderson, of Winnipeg, and others.

C. A. Mullen, director of the paving department of the Milton Hersey Co., Montreal, discussed "The Contract and Specifications for Paving." Abstract of his paper appears on page 328 of this issue. A. F. Macallum, works commissioner of Ottawa, led the discussion, agreeing with Mr. Mullen that sheet asphalt pavements can successfully be laid by cities by day labor, and also agreeing that the guarantee clause is unnecessary in contract paving work. Mr. Near, city engineer of St. Catharines, Ont., called attention, however, to the fact that a 5 or 10-year guarantee is wise in Ontario towns and cities where the property owners pay for the pavement but not for its maintenance, and through the guar-

antee clause they are really made to pay part of the maintenance, as they pay the insurance on the life of the pavement or on part of its life.

"Sheet Asphalt Pavements," by T. Linsey Crossley, of J. T. Donald & Co., consulting chemists, Toronto, discussed the essentials of this type of pavement, the preparation of the specifications and the tests of the materials. An interesting article on these points, by Mr. Crossley, was published in *The Canadian Engineer* for February 22nd, 1917.

Arthur H. Blanchard, professor of Highway Engineering at Columbia University, New York City, was unable to be present, but forwarded his paper on "Road Oils and Tars," so it was read by Mr. Huber. Among those who took part in the discussion on this paper were Paul Mercier, city engineer of Montreal; Richard McClelland, city engineer of Kingston; F. C. Askwith, assistant city engineer of Ottawa; and W. H. Connell, chief of the Bureau of Highways, Philadelphia. Mr. Connell's discussion was particularly thorough and instructive. He told how traffic mats can be constructed to the best advantage with asphalt or tar oils.

The last paper read before the congress was "The Highway in Relation to Land Development," by Thos. Adams, town-planning adviser to the Commission of Conservation, Ottawa. During the ensuing discussion H. Brad Billings, of Billings' Bridge, Ont., who is one of the most enthusiastic good roads supporters among the wealthier Ontario farmers, having constructed many a mile of county road at his own expense so that he can motor to and from his estates, called serious attention to the fact that Mr. Adams, in his plans for highways and towns, provides no public green, or parking area, for aeroplane landings. The time is rapidly approaching, prophesied Mr. Billings, when aeroplanes will be more popularly used, and in any far-sighted and comprehensive town-planning scheme an area should be assigned where the machines can safely alight, the area being suitably indicated by markings distinguishable from the air by day, and by signal lights at night.

Next Meeting Probably at Hamilton.

A business session of the Dominion Good Roads Association was held Saturday morning at the Chateau Laurier. An invitation was received from the Hamilton Board of Trade, asking that the fifth session of the congress be held in that city. The invitation was accepted subject to the condition that favorable arrangements can be made.

The 1916 board of directors of the association was re-elected for 1917. A few additional directors will be added at the next meeting of the association. The old board was continued in order to allow it to perfect its work of incorporating the association under Dominion charter. The officers are now as follows:—

President, J. Duchastel de Montrouge, city engineer, Outremont, P.Q.; vice-president, S. L. Squire, Waterford, Ont.; secretary-treasurer, Geo. A. McNamee, Montreal; honorary presidents, U. H. Dandurand, Montreal; W. A. McLean, Toronto; B. Michaud, Quebec; and O. Hezzlewood, Toronto.

The directors of the association are the above officers and Thomas Adams, Ottawa; A. L. Caron, Montreal; E. A. Cunningham, Lethbridge; Dr. E. M. Desaulniers, St. Lambert, P.Q.; A. C. Emmett, Winnipeg; R. S. Henderson, Winnipeg; Geo. Hogarth, Toronto; J. W. Levesque, Montreal; A. F. Macallum, Ottawa; P. E. Mercier, Montreal; and J. A. Sanderson, Oxford Station, Ont.

THE CONTRACT AND SPECIFICATION FOR PAVING.*

By Charles A. Mullen,
Director of Paving Dept., Milton Hersey Co., Limited.

IT is only necessary to look at the contract and specification forms in use by our many city, county and provincial road departments to realize that the importance of this subject either has not been fully grasped, or, if understood, has been sadly neglected. For my part, though I have had occasion to examine and study many paving contracts and specifications, I have never found even one that seemed to be a finished product; or, in fact, any more than the throwing together of many more or less disconnected sentences and paragraphs. When it has fallen to my lot to prepare such documents, I am free to confess that I have added but little or nothing to the art, and that I am no more pleased with the form and lack of completeness of my own products than with those of my contemporaries.

Some one has aptly remarked that a short contract makes a long law suit. It may well be added that a poorly drawn contract makes a long law suit still longer. I do not know that anyone has ever estimated the cost per square yard of the many litigations growing out of road and street paving work, but certainly this can be no inconsiderable amount. To the judgments and law costs paid directly by public bodies must be added that part of a contractor's contingency figure included in his bid price to cover probable legal expenses. It may truly be said that, no matter which side wins the law suit growing out of a paving contract, the public always loses. If it wins the suit, it loses possibly not so much; but it should be remembered that the contractor's losses and expenses always go to make up other contingency items. Therefore, it behoves those entrusted with the design and construction of public road work to do all in their power to reduce the possible causes of such law suits.

The Relations Between Contractor and Engineer.—The relations between the road department and the paving contractor are no different than those existing between any other buyer and seller. Their interests are diametrically opposed. The main reason a contractor builds a road is for the profit there is in it. With him, use is a secondary matter; in which, if he is in the better class of his calling, he is mildly interested. Where road paving is done on a strictly competitive basis, no matter how high a contractor's ideals may be, or how much secondary pleasure he might be able to get out of doing a good piece of work, the least that the road department can be induced to accept is the most that any contractor can afford to give. After all, the standard of road construction in any community is not so much the letter of the contract as the interpretation of it that the road authorities are accustomed to permit in actual practice. A well-drawn contract and specification is a prime necessity, of course; but with it, competent supervision and careful inspection are also indispensable to good roads.

Nothing in the foregoing paragraph is intended in any way as an aspersion upon contractors. As fine men may be found amongst them as in any other walk of life. They are quite as human as other people, and equally governed by their practical necessities. In justice to him and to the public alike, a better understanding between the contractor and the road department is essential if we

*Paper read before the Dominion Good Roads Congress. Ottawa, April 10th to 14th, 1917.

are to get the best results obtainable through the contract system. Being in many respects the underdog, the contractor will, in nearly every case, be found ready and anxious to co-operate in matters that promise to bring about that better understanding. Fully realizing that the basis of their relations to the road departments is the contract they sign and the specification for the work that accompanies it, any forward step looking to the improvement of these documents by making them more practical and definite will meet with very general support from at least the better element in the road-building fraternity. These men will also be found quite ready to submit to the most rigid systems of direction and inspection; provided the work is carried out in a commonsense way, and provided that it is known in advance of the bidding that even-handed justice will be dealt out to all parties alike.

Contract: An Agreement Between Equal Parties.—In the first place, the contract should be in the nature of an agreement between equals; one of whom is ready and willing to deliver the goods specified, the other, ready and willing to pay the price stipulated. Many, in fact, most of the paving contracts that I have examined, and some that I have been bound by, more nearly resemble a master-and-slave contract. The engineer, especially if he is a man of superficial understanding, always poses as master to the contractor's slave. Since freedom-of-contract is very largely a legal fiction, one should not be surprised to learn that, as soon as they have signed such one-sided documents, most contractors have the feeling that anything they can get away with is theirs. Some engineers,—and I have one in mind who rode on my neck for several unpleasant months,—do not even admit that their interpretation of the contract must necessarily be reasonable. The contractor, especially if he is a man of small finances, must often grin and bear this attitude of the engineer; denying himself even the luxury of telling the man what he thinks of him until the work is completed and the money collected.

Now, such a condition of affairs is not conducive to the best results in road building. No matter how clever an engineer may think himself, the contractor who feels that he is being badly used can deliver and collect for a job that is much less than the best that is possible under the agreement, even though he save no money to himself thereby. Inversely, an engineer who is ill-disposed to the contractor working under him can always cause more expense than is actually required to do the work properly, especially if such engineer is armed with the too common poorly drawn specification coupled to the master-and-slave form of contract. While it is true that the interests of the contractor and the interests represented by the engineer are opposed in the major premise, there is no reason why both parties should not candidly recognize this fact, and then go ahead, with the least friction possible, to the building of a good road. One of the prime necessities of team work between engineer and contractor is that each thoroughly understand and respect the rights of the other. As a basis for this, there must be the well-drawn and easily understood contract and specification in which what each party has agreed to do is clearly stated. Enough unforeseen details will then crop up, during the progress of the work, to call for the exercise of good sense and a sweet temper between even well disposed men.

Some Work that Should Precede the Contracting.—No engineer is fully competent to draw a road or street paving contract until he has made certain preparatory moves. We will assume that the selection of the road site and the proper attention to drainage are accomplished facts, that the traffic is sufficient to warrant a hard road surface, and that the money can be made available. It is up to the engineer to determine what kind of pavement can be laid to the best advantage, and to draw a contract and specification therefor preparatory to accepting bids from contractors. If the work is to be done by direct employment, the contract form may be dispensed with; but the specification should not be omitted, though it may be shortened. There is no reason why public employees doing road work should not live up to just as strict specifications as would be imposed upon a contractor doing similar construction.

It is doubtful if any two paving situations are identical, though most of them closely resemble each other in many important details. Therefore, prior to making the important decision as to what type of pavement to lay, the engineer should very carefully study all the different forms of construction that are possible, the available materials therefor, and the costs and other factors involved. He should be thoroughly conversant with not only the prices that have been bid by contractors at previous lettings in his neighborhood; but, by having made his own careful detailed estimates of actual costs of labor and materials, he should also be in a position to know if the prices formerly charged were reasonable, and whether or not he can lower them by good management and fair dealing. Some well-known paving reports have been based on absolutely false values because the engineers making them either did not know enough or did not care to look into the matter of actual costs. Needless to say, such practice as this is entirely indefensible, and quite justifies the assumption on the part of those who read such reports, and know the things that they do not say, that some of our professional brethren have fallen by the wayside.

The Contract Fair, the Specifications Clear.—In many contracts, it is stated that certain things must be done when the engineer has no intention at all of demanding them, and other things are expressly prohibited that in practice the engineer will quite properly permit. Such a contract is not fair to the contractor. What is necessary should be stated; what is not necessary should be omitted. The requirement for planking a concrete foundation to haul upon it after it has been down seven days is such an instance. Few engineers enforce this clause; and if one did, I should be very suspicious of the quality of his concrete. Any pavement foundation that has set seven days and will not then carry without risk the hauling incident to further construction is not fit to accept. Planking grade is also frequently required in the contract when it is unnecessary and not demanded in practice; unless, perchance, the engineer wishes to punish his "slave." Can one blame the slave if, in order to get even with his "master," he stays awake nights devising a scheme by which he can use two bags of cement instead of three under his master's very nose? This is being done every day; but sad to relate, it is the public and not the engineer that sustains the loss.

In drawing the specification, the rule should be: A reason for everything, and everything in its place. Can engineers much longer go on specifying things that they do not understand? The unfortunate attitude of many public bodies in thinking that, because they have hired a man who is a graduate engineer, he should be able to solve every problem submitted to him without special assistance, is the cause of more poorly drawn specifications than anything else. I have sometimes noticed that the smaller the salary an engineer receives, the more he is expected to know. The poorly paid village engineer,

who is expected to know it all, and is thought to be too expensive even at that, finds himself compelled to get along as best he can alone in order to hold his livelihood. The result is a brave attempt at a specification that is taken in chunks from standard and other specifications; and through which, when it comes to a law suit, the contractor and his attorneys can drive a team of horses at most any point. It is all that could have been expected from the engineer under the circumstances. Family doctors are not expected to perform appendix operations; and those who require it of them must expect to suffer in the process of cutting.

Engineer to Guarantee; Not the Contractor.—As paving engineers, why do we ask a contractor to guarantee the work that we design, direct and inspect? We tell the contractor what to do, how to do it, and when. If the pavement goes wrong,—barring absolute fraud, of course,—why should the contractor pay the penalty? Fair play demands that the engineer guarantee his own road. I do not mean to actually suggest that he be asked to give a bond and make good the loss, but that the contractor should not be required to make good a failure if it is in no way his fault. The engineer's reputation should suffer; not the contractor's pocket, and through him, the public's. If this rule held true, engineers would be much more careful in the paving work that they specified and constructed. I have noticed that the contracts which leave the contractor with the least to say about how the work shall be actually done, also frequently bind him the tightest with a guarantee of the result. This is an element of chance that is forced upon the contractor; and, as with everything else, he of course figures on it in his bid.

Mr. E. M. Perdue, of Kansas City, has remarked that the guarantee is a two-edged sword which cuts the taxpayer both ways. Mr. J. W. Howard, of New York City, opines that what we want are good pavements on our streets, not guarantees on paper. I agree with them both. The practice of requiring a five or ten-year guarantee on paving work has done much harm in the past, and will probably live enough longer to do more harm in the future. It has been the excuse offered by innumerable city officials for not bothering about good inspection and careful testing of materials; and it has been productive of more expensive law suits between city and county governments and contractors than any other one item. We have already remarked that all law costs find their way to the ultimate consumer, who is always the public. Verily, he gets it both coming and going, especially if the engineer has shirked his responsibility upon a guarantee company and permitted the laying of a poor pavement.

Testing and Inspection a Sound Investment.—If the money paid for guarantees to contractors, and, through them, to the bonding companies, should be put into the actual road work in the form of careful testing and inspection, the yield from the investment would on the whole be much greater and far more satisfying. Why be content with the five-year guarantee of a pavement on a street where that type of pavement should last twenty-five years; and on heavy traffic roads and streets, why force the contractor into the position of a gambler? Is it reasonable that he will be able to make any better guess than the engineer on the probable life of the pavement that the engineer has himself designed, the construction of which he has supervised, and the materials for which he has or should have tested and approved? No one takes a business risk these days without a sufficient premium, and the overhead costs and profit expected from such risks is easily one-hundred per cent. That is the figure for fire insurance, when the totals of losses paid is one-half the amount of the gross premium receipts.

Now, it sometimes happens that good construction of some type costs no more than the poor constructions that are permitted where there is no sufficient inspection and testing and no one in consultation who is possessed of the special knowledge required to differentiate. This will even happen where the testing is well organized if the directing force is not what it should be. Testing alone is not sufficient. Many can make the bare tests more or less well who do not recognize the significance of the results after they have got them, and who do not know how to go about correcting the defects indicated by the tests. To be of certain value, the scientific work should begin with a study of the sources of supply of the materials, the costs of securing them, their proper selection and combination regulated by field tests, and the final laboratory analyzing and testing of the finished product as a check upon the practical work that has been done in the field. Only in this way can a road department be certain that it is not squandering the public funds in under-grade work.

Have Nothing to Offer; Wish to Start Something.—I have nothing to offer in the line of a satisfactory plan for the general improvement of road and street paving contracts and specifications at the present time. Some particularly flagrant instances of defective documents, and their consequences, have come under my observation recently, and it is the deep feeling engendered by these instances that makes me willing at this time to help start something in the nature of an organized advance along these lines. I do not know yet what I may be able to do, but whatever part of the work of reconstruction comes my way, I shall be ready to do it. Such work, however, is usually the combined effort of many; and I see no reason why we should not find in the Canadian and International Good Roads Congress an organization through which effort in this direction may be centralized and made to bear good fruit.

I have not in mind the issuance of additional standard specifications; though there is, of course, still much to be done in that line. The matter that seems to me to be of the greatest present importance is the proper use, by local adaptation, of even those standard specifications that are extant. When one has found cities using sections from such standard specifications in such a way that they were putting themselves in the position of advertising for something that could not be delivered from their environment, and could only be secured at a cost that they had no intention whatever of paving and should not pay, it is time to realize that something more requires to be done than the adoption and promulgation of standard specifications. In order to get a standard that will be possible in most sections of a country, much has to be sacrificed that can later be cured by adaptation of the general specification to fit the special needs and local advantages. It is time we bestirred ourselves to do this work of adaptation; and much other work in the proper drawing of a contract and specification besides.

A meeting of the Council of the Royal Architectural Institute of Canada will be held at the Chateau Laurier, Ottawa, Ont., on Saturday, April 28th, 1917, at one o'clock p.m., for the consideration of very important matters, to decide where and when the Tenth General Annual Assembly will be held this year, the creation of the R.A.I.C. Medal, the celebration of the Tenth Anniversary, etc. Hon. Secretary, Alcide Chaussé, Montreal.

HIGHWAY BRIDGES AND CULVERTS.*

By W. G. Yorston, C.E.,
Assistant Road Commissioner, Province of Nova Scotia.

THE agitation of late years for better highways has involved much more than the grading and surfacing of the roads, as one of the most important items to be looked into and dealt with has been the question of highway bridges and culverts. That this is so is due to two causes. One of these is that when permanent improvements are to be put on any section of highway many of the old structures are found too far gone to be of service and have to be renewed because of their old age. There is, however, a second very important factor entering into the matter, and that is the size of the load which has to be taken care of at the present time, due primarily to the advent of the motor truck and its rapid development, and in consequence of the heavy individual loads carried by these vehicles, structures which were thought to be built permanent enough to render good service for many years have to be replaced, not being thought safe enough to carry traffic.

On any length of highway the bridges are the spots of special danger, and it, therefore, becomes necessary to take the greatest care to make these crossings as safe as they can be made in order to carry traffic without accident. A bridge, to be satisfactory, must fulfil three main requirements: It should be strong. It should be durable. It should be sightly and of pleasing appearance. The first of these requirements is altogether a matter of design, and almost any structure can be made strong enough if enough material is used in building it and it is properly placed. The second desirability that the structure should be durable can also be readily obtained by building only of durable material. The third condition, however, is the one in which so many of our structures fail, as sufficient care is not taken in the designing of the bridges to obtain that result or effect which makes all the difference between something pleasing to the eye, and which blends with nature, and something in which the discord is so great that it cannot help but be noticed.

Steel Bridges.—In the province of Nova Scotia the construction of steel bridges was commenced in the year 1883, and since that time upwards of 800 steel bridges of different spans have been erected. Previous to the year 1883 the bridging in the different counties was under the control of the municipal authorities, and the bridges up to that date had practically all been built of wood, and in most cases the substructure for these bridges was also built of cribwork. Steel has been substituted for these wooden structures almost altogether since that date, and at the present time only a few samples of the original constructions in wood are to be found throughout the province. Some of these bridges have been in use about fifty years and are still in a state of good preservation, and are doing good service at the present time.

In the specifications in use in the province of Nova Scotia the steel bridges are divided into three classes as regards live loads:—

Class "A"—For bridges subject to heavy city traffic.

Class "B"—For bridges on country roads with heavy traffic.

Class "C"—For bridges on country roads with light traffic.

The live loads for which they are designed are respectively 15 tons, 12 tons and 8 tons. In the construction of steel bridges the types preferred are as follows:—

For spans up to 30 feet... Rolled beams.
For spans from 30 to 80 feet Riveted pony strusses or plate girders.
For spans from 80 to 200 feet . ..... Riveted trusses.
For spans over 200 feet... Either riveted or pin-connected trusses.

All steel bridges are now designed to carry concrete floors with wood block or bituminous wearing surface, although at the present time these materials are not used universally, as it is found that with the present prices of materials plank can usually be delivered at the bridge site for $20 per M., or under, and in consequence a double floor of planking can be maintained at cheaper cost than the more permanent concrete floor and wearing surface. On all more important bridges, however, it is intended to use concrete flooring.

The concrete floor is heavy and adds very considerably to the amount of dead load of the bridge, and, consequently, increases the weight of the steel required in the trusses. One great advantage of concrete floors in addition to their durability, is that they distribute the concentrated load very much better than the wood, as the weight of passing traffic is spread over a greater area of the bridge structure. The structure is also much stiffened when a reinforced concrete flooring is used.

After a steel structure has been erected and properly field painted, it should remain in good condition for a period of from four to five years, depending largely on the condition of the surface of the steel, the quality of the paint, and the care taken in its application.

The best practice in purchasing bridges would undoubtedly be to first determine just what type and form the new structure will be, and then to prepare the necessary stress sheets and drawings, so that all who intend tendering for the structure will do so on the same basis. For this work it is best to secure the services of a competent bridge engineer. The cost of the plans prepared in this way is a little more than if they were prepared in the department office by members of the regular staff, and in addition the benefit is obtained of greater experence and the consequent assurance of safety.

Concrete Bridges.—Concrete for bridge substructure has been used very largely in the province of Nova Scotia since the year 1883. Dr. Martin Murphy, who was at that time and for many years after the Provincial Government Engineer for the province of Nova Scotia, is regarded by the profession as one of the pioneers in concrete construction, and many of the structures erected of that material bear witness to the wisdom of Dr. Murphy's choice of material.

A paper on the subject of "Bridge Substructure and Foundations in Nova Scotia" by Dr. Martin Murphy, which was read before the Engineering Congress at the Columbia Exposition in 1893, elicited much favorable comment at the time, and also affords much valuable information relative to the employment of concrete in bridge work.

The experience so far gained in the employment of concrete for bridge substructure in the province of Nova Scotia would go to show that it is eminently suited for the work for which it has been used. At the same time it cannot truthfully be said that none of the construction has so far shown signs of deterioration. It is the case that concrete has been employed in Nova Scotia in as

*Abstract of paper read before the Dominion Good Roads Congress, Ottawa, April 10th to 14th, 1917.

difficult situations as are to be met with anywhere. The bridges constructed over many of the tidal streams entering the Bay of Fundy where concrete has been employed are exposed to heavy abrasing conditions due to heavy currents, and are, in addition, exposed to frost effects for a wide range of tide, sometimes as great as thirty feet. Under such conditions it is not remarkable that some deterioration has taken place. On the other hand, it can truthfully be said that concrete in these situations has shown itself at least the equal of cut-stone masonry. Where concrete has been employed in other situations, not exposed to tidal influence, it has been found to be entirely satisfactory. It must not be forgotten, also, that in the early days it was difficult and almost impossible to secure skilled foremen for concrete work, and part of the deterioration which has taken place is due rather to defective construction than to any imperfect concrete material. Concrete is now used almost universally throughout the province of Nova Scotia for bridge substructure, and also for masonry culverts where these have been built.

Concrete bridges are built in three general forms: (1) Arches. (2) Girders. (3) Trusses. Few concrete trusses have so far been built, and this form is so rare that is hardly need be discussed. Concrete arches can be used for all spans. Especially for the longer spans it is the most pleasing and graceful form in which concrete can be employed, as the lines of the arch particularly lend themselves to a beautiful outline. Of all the types of concrete bridges, the arch is the favorite, and it is also perhaps more often employed. Girder bridges are very useful for spans between eighteen and forty feet, but this form of bridge is much more severe in outline than the arch and cannot be made as pleasing to the eye.

Sand tests are as important as cement tests, and should be made regularly. In order to secure uniform strength, the proportion of the different materials required should be accurately gauged.

Where reinforcing is used in concrete, care should be taken to have it accurately placed and spaced. The steel should be carefully wired in place according to the dimensions on the plans, and in the placing of the concrete great care should be taken that the steel is not disturbed. All reinforcing bars should be free from scale, rust or grease, which tend to decrease the bond if left on the iron.

Culverts.—Pipe culverts are generally used up to a diameter of two feet, and in many instances to three feet. These pipes are of concrete or vitrified clay, and when used must have a sufficient covering of earth to protect them from traffic. Culverts of this class require to be laid in good manner and with a good grade, so that the water will not stand in them. It is most important, also, that a good outlet be provided to carry the water freely away from the structure. Great care should always be taken to have the pipes carefully laid on even bearing and the filling around them properly compacted. There should be at least fifteen inches of earth over the pipe when it is laid in order to properly protect it from the wheels of passing vehicles. For waterways requiring more than three square feet of opening, box or arch culverts are generally used, and these are usually built of concrete. Masonry ends are built on all pipes to protect them from breakage, and also to prevent water from following along the pipe. Inlet and outlet ends should be paved to prevent scour.

Records.—Records of larger bridges for the office are most important, as it is always essential that it should be known just what the cost for construction and maintenance of the different structures has been. This is especially important in the case of bridge painting, as it is only by such means that any accurate idea can be had, both as to the cost of the work and the anticipated requirements in any season. A good system is to keep a card record on cards six by eight inches. On the face of the card is given all important information regarding the construction of the bridge, its dimensions, cost, etc.; in fact, all essential information can be given in concise form in this manner. On the reverse side of the card provision is made for records of the cost of repairs and painting. The painting record should show the kind of paint used, the time of year in which the bridge was painted, and its cost. From such records as these it is possible to tell at any time the state of repair of all structures on the different highways. As it is too cumbersome and perhaps unnecessary to file individual records for the smaller structures, these can be grouped together in sections in any way desired.

The structures must be treated as an integral part of the roadway and to meet the demands of traffic, especially of safety, all parts of the roadway must be wide enough to carry the traffic without danger. To this end all the structures must be made of such dimensions as will allow the maximum width of roadway demanded. All parts of the highway should be kept in good condition, and it is of little use to have well surfaced and smooth roads if the bridges are not strong or are unsafe; nor is it good business to have all the bridge structures of the most substantial and ornamental character if quagmires exist at either end of these structures. On the contrary, the whole scheme must be balanced in order to get the best results. Quite true, the element of safety in highway structures must never be lost sight of, but it is quite possible, also, in the fervor of erecting permanent bridges and culverts, to erect these at too great a cost, leaving not enough money to finish up all parts of the highway to the same standard. All engineers take the utmost pride in building their structures permanently, but at the same time there is a feeling that the garment should be cut to suit the cloth, and the expenditure should be made to suit the circumstances, and where it is demonstrable on any road of little traffic that structures of wood can be kept up for a fraction of the interest and maintenance costs of permanent bridges, then the cheaper structure should be built, and the money so saved should go to the main arteries which, in most instances, owing to the greater traffic conditions, are generally in need of more money than is available for their construction and upkeep. No general lines for these expenditures can be laid down, but each must be considered on its own merits and dealt with accordingly.

EMERSON GOOD ROADS ASSOCIATION.

A large number of representatives of southern Manitoba municipalities attended the annual meeting of the Emerson Good Roads Association, held recently at the Russel House, Emerson, Man.

It was unanimously decided that the movement for securing better roads should be continued during the coming season, and last year's officers and executive were re-elected. They are: Reeve J. McCartney, Franklin, president Mayor E. Casselman, Emerson, vice-president; and R. E. Masterton, secretary-treasurer.

BITUMINOUS MACADAM ROADS.*

By Wm. D. Sohier.
Chairman, Massachusetts Highway Commission.

I HAVE been requested to speak about bituminous macadam roads, particularly those built by the penetration method. In Massachusetts we have used both tars and asphalts, using both the penetration and the mixing methods.

The Highway Commission has just made its 24th annual report. We began to construct our state highway system 24 years ago, and the highways that were built then are still in existence, though naturally the older roads have required resurfacing.

Ever since the motor vehicles became so numerous, the number using the roads about doubling every three years, the older roads have been worn out very fast.

We have now on our main highways during the summer season an average of over 700 motor vehicles a day, and on the roads with heavy traffic 2,000 to 3,000 a day is not unusual.

Consequently, we have had to prevent our roads from being rapidly destroyed by the use of some form of bitumen on the surface at least.

Motor trucks are now increasing rapidly. Our older roads, which were built of a standard width of 15 feet of macadam with a three-foot shoulder on each side of gravel or the best material obtainable, are too narrow for the increased traffic and should be widened.

This will tend to distribute the traffic and make the road surfaces wear longer. We are now building our new roads at least 18 feet in width of hardened surface, with a three-foot shoulder on each side. In some cases, on hills especially, etc., we are trying to secure six feet on the side, of waterbound macadam or gravel for the use of horse-drawn vehicles.

On most of our main highways, whether State highways or town ways, some form of bitumen has had to be used on the surface at least, or the motor vehicles would tear up and destroy the roads in a few weeks. This brings me to my topic, "Bituminous Construction."

For the last few years, because of the number of motor vehicles using our roads, we have found it necessary to build some form of bituminous pavement or else to build a road of cement concrete.

We have used this form of construction on all main lines, not only in construction, but when the road was resurfaced.

Bituminous Surfaces.—Another change that has been made, because of the increase in the weights that the roads had to carry, has been the use of the larger crushed stone (2½ inches) on the surface of the road.

We have used both tars and asphalts in penetration work. The methods are much the same.

After we have secured an adequate foundation, well compacted and rolled, we have spread on this enough broken stone to make it four inches deep after rolling. It has been thoroughly rolled until it will not creep under the roller. On top of this we have spread about 3 inches of 2½-inch stone, and rolled this thoroughly down to about 2 inches.

Into this top surface we spray hot asphalt or tar, under pressure, using one of the various mechanical sprayers or trucks. The asphalt has to be heated to about 350° F., the tars to about 250° F.

We spray in about 1¾ gallons to each square yard of surface, finding that this hot bitumen will penetrate about 2 inches, coating the stone.

We then spread all the ¾-inch stone that can be rolled in, and roll it thoroughly, thus filling the voids in the surface.

After this is done all surplus stone is thoroughly swept off with bamboo brooms, and a surface coating of asphalt or tar, ½ to ¾ of a gallon to the square yard, is sprayed onto the road.

This is thoroughly covered with peastone and well rolled. This peastone has to be constantly swept back or more stone added for a few days, until there is no sign of bleeding.

When any work of this character is done in cold weather, the road must be carefully watched every warm day, and especially the next season, and wherever there is any indication of bleeding more stone or gravel must be spread on it immediately, or the road will be picked up by the passing vehicles. Covering must always be kept on the road until all the bitumen has been taken up; otherwise teams, trucks and automobiles will pick up the surface on their wheels.

We spray the bitumen on one-half the road surface at one time, cover it, etc., and then do the other half of the width.

The ¾-inch stone and the peastone are got out beforehand and stacked on the roadside, so that the covering can be put on immediately and the stone rolled in before the bitumen cools.

We hope and believe that roads of this character built on an adequate foundation and properly maintained will carry a very considerable traffic for five years at least, before they need a new surface treatment, when a good grade of the asphalts is used. Where tar is used our experience, in common with the best English practice, seems to show that a light surface treatment of about ¼ gallon to the square yard is advisable and necessary every two years. (I can give anyone figures in detail.)

Wages were so high with us in 1916 that all our costs increased nearly or quite 50 per cent.

In 1915 the cost of this penetration work was as follows: For the 4-inch lower course and the 2-inch upper course penetrated with bitumen:—

Uxbridge—$1.02 per sq. yd.; trap; oil asphalt, $.08¾ a gallon; 110 penetration.

Dedham—$1.25 per sq. yd.; trap; bermudez, $.12½ a gallon.

Saugus—$1.06 per sq. yd.; trap; tar, $.07¾ a gallon; viscosity, about 125.

Middleton—$0.81 per sq. yd.; local stone; tar.

Cost of some resurfacing work, penetration method, in 1916:—

Weyland and Sudbury—$1.30 per sq. yd.; trap 6-in. to 7-in.; bermudez, $.12½ a gallon.

Shrewsbury—$.98 per sq. yd.; trap, 5-in.; same bitumen.

Northboro—$.79 per sq. yd.; local stone; same bitumen.

Tar-Sand Grout, Brodie Method.—Mr. Brodie, city engineer of Liverpool, and one of the most experienced road builders in the world, has developed a form of construction that he believes will and has proved economical for ordinary light city traffic but not for heavy teaming.

Certainly when some of his roads were 12 years old, in 1914, the roads built by this method were in most excellent condition. They had not been patched or resurfaced, whereas the waterbound macadam road just beyond, carrying the same traffic, had been lightly resurfaced every year.

*Abstracted from a paper read at the Dominion Good Roads Congress, Ottawa, April 10th to 14th, 1917.

The usual method is as follows: After the foundation is properly prepared and well compacted, about 4½ inches of 2-inch to 2½-inch stone is spread and well rolled. This is grouted with pitch and sand mixed and kept constantly agitated. They then spread and roll in with a steam roller, stone of about 1½ inches, which is grouted with pitch and sand and rolled down with a steam roller, the wheels of which are kept constantly wet. Into this top they roll chip or ¼-inch stone.

During the last few years they have been putting on a surface application of the pitch and sand and covering it with peastone, all well rolled.

In Liverpool the tar and sand is usually heated at a central plant and hauled to the road by a steam tractor. The tar and sand is mixed in a "dandy," which is a two-wheeled, 35-gallon tar kettle. They use about an equal quantity of tar and sand, to 60 per cent. sand. This is mixed and kept constantly agitated by a man with a paddle. The men pour it by hand from buckets that hold about 1½ gallons, pouring it very evenly.

The sand used is a fine sand about like the sand used in plastering.

The important point is to secure a sand that is the right size to stay in suspension in the tar and not settle to the bottom too quickly. Of course, the coarser the better, if it can be kept evenly in suspension until used.

The tar and sand are both heated to about 250° F.

Mr. Brodie, if I remember correctly, figured the additional cost of this work over and above the cost of a waterbound macadam road, at from 25 to 35 cents a square yard.

Where we have constructed some roads of this character, we have heated our sand and tar on the roadside, using tar kettles and a sand heater to heat the sand. We built a box on wheels, sloping to the end, and had a flexible pipe with a flat nozzle from which the tar and sand mixture was poured into the road.

In Natick, where some work of this character was done in 1914, the old macadam road was scarified, about 2 inches of 2½-inch stone was spread and rolled; this was grouted with the tar and sand mixture, finer stone rolled in, etc., and the cost was about 75 cents a square yard.

The road has been most satisfactory, and it certainly looks now as if it would last for 10 years at least, on a road with about 50 trucks a day and over 700 motor vehicles.

We have used this method of construction on quite a number of stretches of road, especially on grades, as it seems to be less slippery for horses than any other type of bituminous surface, especially if the surface coat is left off and the stones are allowed to project a little.

The tar and sand seems to stiffen and strengthen the whole road, and we believe the use of the sand prevents the tar from oxidizing for many years, and thereby adds to the life of the road.

We developed this year a very good contrivance for securing an even distribution of the mixture. Two plank bridges were made that bridged the road. They were 2-inch plank supported in the middle on a 2-inch plank on the crown of the road and built up on the sides. Another 2-inch plank running lengthwise of the road was supported on these, and the man pouring the mixture walked along this plank, held his bucket right against the plank and walked at a rate of speed that just emptied the bucket in the length of the plank. A flat-nosed bucket was used, with a nozzle about 8 inches in width.

By placing the bridges the right distance apart, one bucket covered just the proper area, and we poured about 2 gallons to each square yard of surface.

Keeping the bucket against the edge of the plank secured a straight edge on the road. The plank was then moved along on the bridges across the road, and the process repeated, until the whole width was done. There were practically no spaces left where the voids were not filled and the bitumen did not lap.

By keeping the same men on the pouring and having the hot mixture brought to them, uniform results were insured and the work progressed rapidly.

In England, in several instances, I think in all where they were rolling either a sand-pitch grouted road, or grouting with tar a stone road, they were wetting the wheels of their roller. In one or two cases they had a man on each side constantly pouring water on the roller wheels. This was to prevent the tar from picking up on the wheels of the roller.

In Liverpool, they make a little ordinary water box and place it over the wheel of each roller. In the bottom of the box they leave a little opening on one side, and put in a piece of crash or linen towelling, which hangs down over the roller wheel and keeps it just moist, the roller man filling the box from time to time with water. They say it does not need much water but merely enough to keep the wheels of the roller damp, and when they tried other methods they got too much water and it interfered with the hot tar surface, pitting it. The box is just the width of the roller wheel, about a foot to fourteen inches square. When they used too much water, they got blowholes in the tar.

Gravel Asphalt Mixed Surfaces.—There are two forms of bituminous construction that we have used with considerable success in Massachusetts, that certainly until a year or two ago have not been used elsewhere, to my knowledge.

The processes are about the same, except that in one case sand is used combined with an asphalt, by either the layer or mixing method, and in the other case a sandy gravel is used combined with asphalt.

We have constructed a good many miles of road where these materials have been used. They make very satisfactory roads for medium and light traffic, and cost comparatively little to build.

We do not claim even for the gravel asphalt road that it is superior to various other forms of bituminous surfaces, which cost a good deal more to construct, but that where stone is expensive, the haul long, if a good quality of sandy gravel may be obtainable at a very low cost near the road, in many cases a road can be constructed using this material, the first cost of which will be relatively low.

A short description of the process of construction will be of interest. For instance, in Shirley, Mass., a road, 18 feet in width with 3-foot shoulders, was built, the curves being banked and widened to 21 feet. A gravel foundation was put in wherever the bottom was bad, and about 4 inches of local crushed stone was spread and well rolled.

On this was spread, as evenly as possible, about 3 inches of a bituminous mixture, made of gravel that had been run through the crusher, and sand or stone dust, mixed with a heavy asphaltic product.

The gravel and sand and the asphalt were thoroughly heated and were mixed in a hot mixer, and then carted onto the road and spread. The surface was rolled down to about 2 inches in thickness, when the mixture was sufficiently cool not to crawl under the roller.

Great care is necessary to insure a uniform product, uniformly heated, mixed and spread, and that sufficient Mix, 1 to 6 of pit gravel. Transverse joints every 30 ft.,

asphalt is used and no more than sufficient to bind the mixture properly.

The quantity of asphalt has to vary somewhat, according to the amount of voids in the mineral aggregate. The variation is usually from 18 to 22 gallons of the cold asphalt to the cubic yard of gravel. When the mixture is right it has about the consistency of brown sugar, and compacts under the roller, though when it is first spread and rolled it sometimes has a few hair cracks which the traffic soon rolls out. The asphaltic product used in this work has a penetration of from 80 to 120 with a Dow penetrometer.

Roads constructed of sand and asphaltic oil were first tried by my Commission in 1905, and that road is still in existence, though it has required a considerable expenditure each year, to keep it up, renew and widen it.

The gravel and asphalt mixture was first tried by me in 1907, and that piece of road is still in reasonably good condition.

Such mixed asphalt gravel roads certainly look as if they would last for a considerable period of time. Several quite long stretches have had already five years' wear. A few, but not many, weak places occur, and these have to be patched, but the expense is very slight.

With the higher wages, the higher cost of all materials, etc., the cost of all road construction has increased.

I am giving below a few of the costs of roads of this character. These costs are all for the 4-inch broken stone base, rolled, with a 3-inch mixture spread on top and rolled to 2-inches. The grading, foundation, if any, drainage, etc., were all additional.

Cost—Gravel-Asphalt Mixture.

Shirley	(1914)	$0.81 a square yard
(Residuum asphalt, 8 cents a gallon.)		
Sterling	(1914)	$1.01 a square yard
Gloucester ...	(1916)	$1.29 a square yard
Andover	(1916)	$1.20 a square yard
Reading	(1916)	$1.08 a square yard

The asphalt used was a residuum asphalt, usually one with some lake asphalt in it. It cost from 9½ cents a gallon to 12½ cents a gallon, depending on the quality.

We used a penetration of about 85 for this character of road.

I will annex some specification forms which can be printed.

I wish to congratulate you on this splendid Congress. I wish to congratulate you still more on the great progress in road improvement that has been made in some of our Canadian provinces during the last few years.

Above all, I wish to congratulate you upon the class of men that you have here interested in good roads. It has been a great pleasure to me to meet so many of them. I have learned much from them. They help us in the States, and we try to help them here.

I hope you realize fully what you owe to these men. Whatever progress you have made is largely due to their devotion to the cause, their knowledge and skill. I cannot name them all, so I will only say to look at the men who have been presidents of your association, and look at the men who have been in charge when good roads have been constructed, and you will see men who have no superiors and few equals in my country or any other.

In conclusion, I wish to say that I very much appreciate the opportunity that has been given to me to come to Canada, especially this year when practically we have vital interests in common, when my country is just beginning the war preparation which you have been so ably carrying on during the last two and a half years.

I only hope that our people will prove as efficient, as resourceful, as unselfish, and as patriotic as the people of Canada have been during these trying years.

We have a great deal to learn, a great way to go, but at least we stand shoulder to shoulder with our northern neighbors, ready, if necessary, to make the last sacrifice, if thereby we can secure to the coming generations of the world "the blessings of liberty" for which our ancestors fought, "the right of seeking and obtaining their safety and happiness" to the end that a government "of the people, by the people, for the people, shall not perish from the earth."

MONTHLY RAILROAD EARNINGS.

The following are the weekly earnings of Canada's transcontinental lines during March:—

Canadian Pacific Railway.

	1917.	1916.	Inc. or dec.
March 7	$2,442,000	$2,198,000	+ $244,000
March 14	2,670,000	2,258,000	+ 412,000
March 21	2,648,000	2,281,000	+ 367,000
March 31	3,932,000	3,491,000	+ 441,000

Grand Trunk Railway.

March 7	$1,063,190	$ 992,026	+ $ 71,164
March 14	1,068,837	957,542	+ 111,295
March 21	1,054,639	967,233	+ 87,406
March 31	1,815,571	1,592,442	+ 223,129

Canadian Northern Railway.

March 7	$ 669,100	$ 540,200	+ $128,900
March 14	738,200	538,000	+ 200,200
March 21	719,100	549,000	+ 170,100
March 31	1,146,000	979,000	+ 167,000

The Canadian Northern Railway February statement is as follows:—

	1917.	1916.	Inc.
Total gross earnings.	$ 2,358,600	$ 2.089,200	+ $ 269,400
Operating expenses ..	2,250.400	1 959.800	+ 290,600
Net earnings	$ 108.200	$ 129,400	
Aggregate gross earnings from July 1st.	$26.822.700	$21.527.600	+ $5,295.100
Aggregate net earnings from July 1st.	$ 6,886,400	5,909,300	+ 977,100

Results of operations of the Canadian Pacific Railway for the half-year ended December 31st last were:—Gross earnings from railway and lake and coastal steamers, $76,717,965; working expenses, $45,643,199; net earnings from railway and lake and coastal steamers, $30,874,766; deduct fixed charges, $5,132,951; surplus, $25,742,215; deduct contribution to pension fund, $200,000.

Deduct net earnings of coastal steamers, commercial telegraph and news department transferred to special income account, $1,144,071. Net revenue from earnings of railway and lake steamers available for dividends, $24,395,144. After payment all dividends declared for half-year the surplus from earnings of railway and lake steamers is $13,684.505.

Special income for the half-year after making allowances for contingent reserves, $6,415,352.

The first foreign shipment from the new plant of the Vancouver Creosoting Co., Ltd., Vancouver, was made about a month ago, consisting of creosoted railway ties for China. The firm expects considerable foreign business when shipping becomes normal.

A preliminary report on the mineral production of Canada during the calendar year 1916, by John McLeish, of the Division of Mineral Resources and Statistics, Ottawa, says: "The total value of the metal and mineral production in 1916, as shown in the preliminary report, was $177,357,454, which, compared with a production in 1915, valued at $137,109,171, shows an increase of $40,248,283, or 29.3 per cent. The previous maximum production was $145,634,812 in 1913.

ESSEX BORDER UTILITIES COMMISSION*

FAR-REACHING RECOMMENDATIONS ARE MADE BY MORRIS KNOWLES, CONSULTING ENGINEER—INTAKE AT LOWER END OF PEACH ISLAND WITH PUMPING STATION AND FILTRATION PLANT ADJACENT — ESTIMATED COST, $1,800,000

THE preparation of this report has involved the study of the various methods available for the water supply and collection and disposal of sewage for Ford City, Walkerville, Windsor, Sandwich, part of the township of Sandwich West, and Ojibway; the preparation of numerous comparative estimates on different projects for accomplishing these ends; and the determination and selection of the most economical project in each case.

Metropolitan Idea.—The co-operation of several municipalities in building and operating public works of magnitude, has been tried with success in all parts of the world.

Population.—It is concluded that the population of the territory under the commission's jurisdiction amounts to 37,467 in 1916, and that it will increase to 110,000 in 1930, to 150,000 in 1940 and to 175,000 in 1950, all within the present limits of the district. This latter figure, however, does not represent the total population that may ultimately have to be provided for; for long before this time, it will be necessary to enlarge the boundaries of the district, if public works are to be carried out in a comprehensive manner.

Quantity of Water Required and Sewage to be Treated.—These subjects are considered together and a careful estimate, based upon the available information, leads us to conclude that Ford City will require one and one-half million gallons of water per day in 1930; Walkerville, one and one-half million gallons; Windsor, seven and three-quarter million gallons; Sandwich, two and one-quarter million gallons; Sandwich West, one and six-tenths million gallons; and Ojibway, two million gallons.

Quality of Water.—In studying the quality of the water of the Detroit River we have had available a great mass of analytical data collected by the International Joint Commission and by the city of Detroit. These data show clearly that the river is seriously polluted by municipal sewage and by the discharge of wastes from boats and that while the pollution increases progressively, downstream, best water being obtainable from the main ship channel near the lower end of Peach Island, no portion of the river can be considered satisfactory as a source of water supply for domestic use, without treatment.

The appearance of the water, also, is frequently unsatisfactory.

Water Supply System and Estimated Costs.—The recommended ultimate water supply system provides for an intake at the lower end of Peach Island, a pumping station on the river front with purification works adjacent, and a trunk pipe line extending through the various municipalities with take-offs at various points to supply the existing distribution systems. The estimated cost of this project is $1,890,000, with annual charges of $209,160.

The immediate improvement of the existing supplies of Windsor and Sandwich and the furnishing at once of a supply to Sandwich West and Ojibway, may be accomplished by the Commission's endeavoring to arrange with the proper Windsor authorities to have the Windsor pumping station operated for the benefit of the four communities named. The 20-inch cast iron pump line recently laid in Windsor might also be used for the same purpose, in which case an extension through Sandwich and Sandwich West to Ojibway, should be made.

The cost of supplying the larger quantity of water would be materially less per million gallons than the cost to Windsor at present, and in addition, Windsor would be compensated for the use of the supply works for the benefit of the Commission. Thus Windsor would be enabled either to reduce her outstanding debentures or to make extensions and improvements to the distribution system, which it would still retain, as is provided and always contemplated by the Essex Border Utilities Act.

The estimated cost of these immediate improvements, including an approximate allowance for the payment to Windsor, if the works mentioned were purchased, is $278,000, and the annual expense is $41,610.

Methods of Sewage Disposal.—Various methods of sewage disposal are discussed in an appendix, and it is concluded that for the local conditions, treatment by settling in two-story tanks, by screening, or by the activated sludge process, followed by disinfection and disposal through multiple outlets in the main channel of the stream, may eventually be required. This agrees with the conclusion of the International Joint Commission's engineers, and also with those of the engineers of the city of Detroit. But this final treatment is not necessary until all the communities on both sides of the river are required to treat their sewage, and for the immediate future, it would appear that all reasonable requirements can be met by the construction of a sufficient portion of the proposed interceptors to permit the collection of the sewage now discharged above the existing waterworks intake, and its discharge downstream and to care for the urgent necessities of Ojibway, Sandwich and a portion of Sandwich West.

Sewage Collection and Treatment Works.—Eight main projects have been studied in detail, and are presented, with estimates. It is concluded that the best and most economical project in first cost and annual operating charges is that providing interceptors on Sandwich, Bedford and Main Streets, which will collect the sewage from the various municipalities, beginning at Pelette Road in Ford City, and at Fourteenth Street in Ojibway, and meeting at a disposal site on Prince Street, between Chewett and Detroit Streets, Sandwich.

The estimated cost of the recommended project, including the Turkey Creek Works, is $900,000; the annual charges (excluding those of the Turkey Creek works) are estimated at $101,000. This estimate is based upon sewers and pumping stations designed for the ultimate population of the territory, with disposal works and pumping equipment sufficient for 1930 requirements.

*Abstracted from Morris Knowles' report on Metropolitan Water and Sewerage Systems for Essex Border District.

As in the case of the water supply, this whole expenditure is not required at once. The most urgent demands are for the collection and disposal of the sewage of Ford City and Walkerville, below the intake of the Windsor waterworks, and the collection and disposal of the sewage from Ojibway and from those parts of Sandwich West and Sandwich which will soon have a considerable population. A program of construction is suggested, the estimated cost of which immediate construction is $210,300; and the total annual cost $18,590. The works proposed are shown in Fig. 1.

The following specific recommendations are made:—

Water Supply.—(1) That the commission arrange at once to operate the Windsor pumping station and the new 20-in. pipe line in Windsor, and adequately compensate Windsor for such an arrangement, and to extend this line through Sandwich and Sandwich West to Ojibway.

(2) That the Commission proceed to furnish water to Windsor, Sandwich, Sandwich West and Ojibway, at cost, but that each municipality control its own distribution system, the delivery of water to its consumers, and the collection of water rents.

(3) That as soon as economic conditions permit, the Commission next proceed to build works and secure a water supply from the recommended source near Peach Island.

(4) That as Ford City and Walkerville at that time may wish to arrange to secure control of the distribution systems within their town limits. In that event, the Commission might arrange for the use or acquirement of so much of the supply works of the Walkerville Water Company as are used to supply water for municipal service within those towns.

Sewerage.—(1) That Ford City proceed to construct the sewer system as designed by Mr. T. Aird Murray, Toronto.

(2) That the sewage of Ford and Walkerville be collected, at once, in an intercepting sewer and delivered to a pumping station near the west main sewer in Walkerville and there lifted to an intercepting sewer, connecting with the Parent Avenue sewer outlet, thus removing all sewage from the river above the present water intakes.

(3) That Ojibway and parts of Sandwich West proceed to construct sanitary sewerage systems, and deliver sewage to an intercepting sewer extending to Park Street in Sandwich, where it will be pumped into the Park Street sewer outlet.

(4) That as soon as economic conditions permit, the intercepting sewers to Parent Avenue in Windsor and to Park Street in Sandwich, be extended to the ultimate disposal site at Detroit Street and that the sewage be there pumped to a detention tank and treated with a disinfectant.

(5) That the sewage treatment works be built when required by the conditions existing in the river or by the action of governmental authorities.

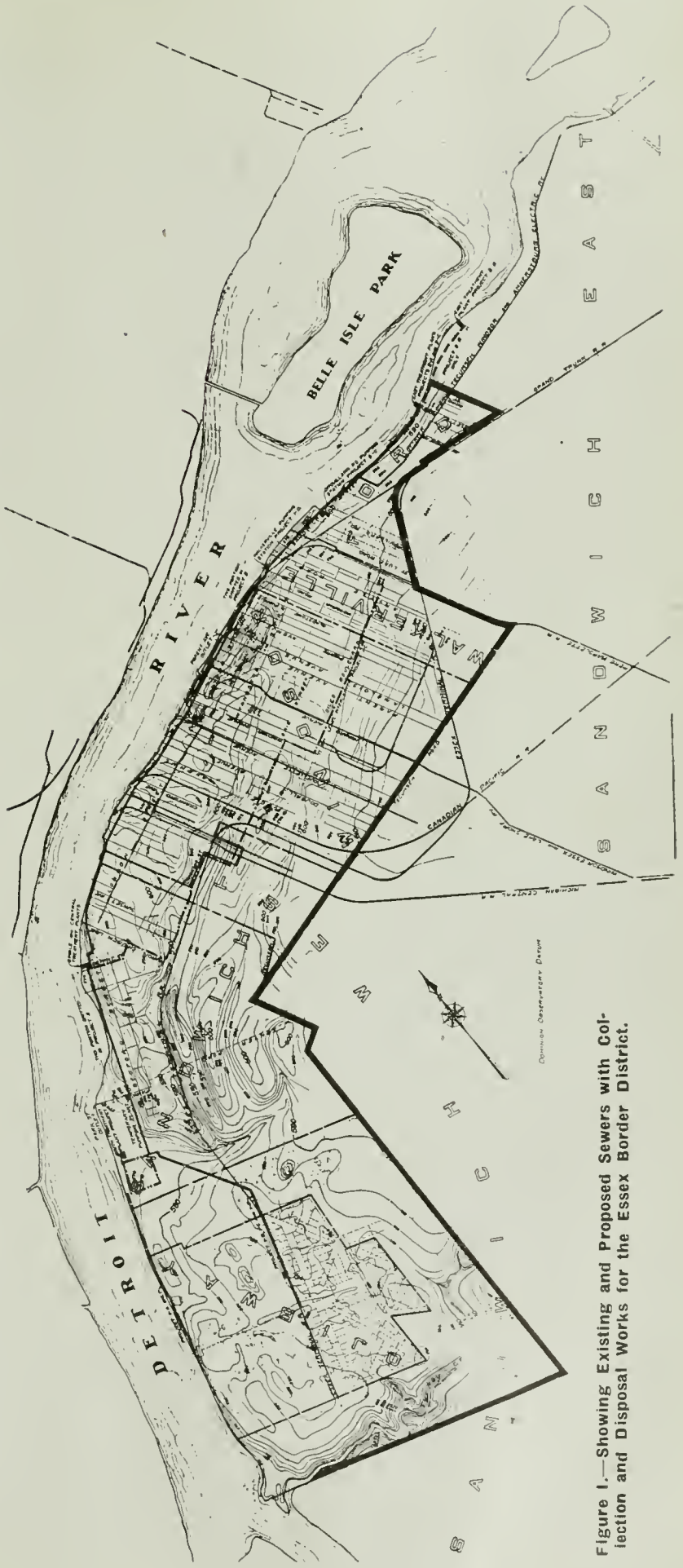


Figure 1.—Showing Existing and Proposed Sewers with Collection and Disposal Works for the Essex Border District.

CEMENT CONCRETE ROADS AND PAVEMENTS.*

By T. Harry Jones, M.Can.Soc.C.E.,
City Engineer, Brantford, Ont.

FOR the past twenty-eight years cement concrete has been used in Canada in the construction of sidewalks. In connection with the earlier walks its use was extended to the building of the walk crossings at street intersections, some of these, built over twenty-five years ago, being in good condition to-day. It was also used as a foundation for sheet asphalt and other pavements. Later, lanes were built of concrete, one having been constructed in Toronto in 1898. It was only ten years ago that concrete alone was used for street pavement, six streets being constructed in Windsor of this material in 1907. Its use has grown till it is estimated that there are about 2,800,000 sq. yds. of this pavement in Canada, of which about 1,600,000 sq. yds. are in Ontario and 600,000 sq. yds. in the Province of Quebec.

In Ontario alone last year there was laid about 370,000 and in Quebec about 100,000 sq. yds., while in the United States, or, I should say, our sister Republic —the name having a new meaning to-day, when she is by our side in the world fight for freedom and democracy—it is estimated there are over 60,000,000 sq. yds. of concrete pavement in use to-day.

In connection with transverse joints in concrete pavements, these are usually termed "expansion joints," and are left ¼ in. in width, and are filled with tar or asphalt. In some cases even wider joints are advocated. During the warm weather, when expansion occurs, the filling is soft and is pressed out of the joint. As abrasion occurs at the edges of the joint, the narrower the joint can be made the better. The writer is of the opinion that in city pavements, which are watered daily, and on residential streets partly shaded by the trees, little attention need be paid to the expansion of the slab. If a simple cut is made through the pavement, which will allow for contraction, and care taken that it be vertical, the adjoining slabs should bear the compression.

In the construction of long stretches of sidewalk a good deal of trouble was caused by the buckling of the slabs during the hot weather. This was completely remedied by leaving a one-inch strip in every city block. Why could not the same principle be applied to pavements, doing away with the cross-joints and leaving a two-inch bridge, say, every 500 ft. in length?

In a two-course pavement constructed in Brantford in 1914 (Park Avenue in the schedule) a strip 1½ inches wide was left between the blocks of the lower course, which was afterwards drawn and filled with sand and the top course of two inches was cut through. No buckling has occurred in this pavement. This matter was also followed in another pavement (Erie Avenue in schedule), which was begun last year and is to be completed this year.

While cracks in all pavements are objectionable and should be eliminated if possible, there has been a great deal more criticism in reference to these in concrete pavements than the facts justify. The writer the other day in a large city counted 120 cracks in about a quarter of a mile on the part (not concrete) between the street railway track and the curb, yet ordinarily they would not have been noticed. Most of the cracks in concrete pavement are in the earlier ones, when the specifications of to-day were not followed.

It will be seen from the schedule that a number of places in Ontario can be cited which have roads with comparatively few cracks, while this, it is believed, also applies to the St. Rose Village Road and many others in the Province of Quebec.

There is no reason why concrete should not be laid on business streets or those subject to heavy traffic. The experience in Wayne county has demonstrated this. The South Market Street pavement, laid in Brantford in 1912 near the intersection of the two main business streets on a grade from 5 to 8 per cent., is another example.

Objection is sometimes made to concrete pavements on account of the difficulty in breaking through in making connections or repairs to services. It seems to be forgotten that the same objection largely exists in other pavements which have a concrete foundation.

The maintenance charges in connection with concrete pavements are less than those of any other class. This will be more appreciable as time goes on, and it is found that other pavements with which concrete is compared require replacing, while properly constructed concrete pavements, instead of lasting their estimated lifetime of, say, ten years, are good for another ten, and still another.

SCHEDULE OF CEMENT CONCRETE PAVEMENTS LAID IN ONTARIO.

Aylmer.—Total number of square yards of one course, 6,681. This was the model road constructed by the Ontario Government Highways Department in 1914 on Talbot Street, one of the leading entrances to the town, and on the main highway from Windsor to Niagara Falls. One-course pavement, 7 ins. thick, 1,918½ ft. long, 30 ft. wide between curbs. Mix, 1 of cement (of which 10 per cent. by weight is hydrated lime) to 4 washed lake gravel. Steel reinforcement. Transverse joints every 30 ft. and longitudinal joints next curb. (A full description of the road in Highway Improvement Ontario 1915 report.) Total number of square yards of two course, 24,336. Average cost, $1.49, including Baker joints, which cost 9 cents per square yard. Base, 5 ins.; mix, 1 to 4 pit gravel; top, 2 ins.; mix, 1 : 1½ : 3. All pavement reinforced. The first section laid in 1913 on a residential street—the main road to the station. Heavy traffic, 28 ft. wide, 7 ins. thick, reinforced ½-in. joints at curb. In 1915 a 5-in. concrete top was laid by contractor on old surface. For 14 ins. from curb existing surface was picked to a depth of 3 ins. to about 5 ft. from curb and holes that had developed dug out to a depth of 7 in. Concrete 5 ins. thick was laid from a point 14 ins. from curb over whole surface mixed 1 : 2 : 4 of stone chippings. Steel reinforcing used with transverse joints every 30 ft. filled with prepared felt. Cost borne by contractor. Pavements laid on business and residential streets. First concrete pavement laid in 1913.

Barrie.—Total number of square yards of one-course, 14,850. Thickness, 6 ins. Mix, 1 : 2 : 4. No reinforcement used. Ninety per cent. of blocks are free from cracks or ones not requiring repairs. Except for 250 ft. over a creek, where sub-grade settled, Tarvia was used in expansion joints and a few large cracks. The pavement has been entirely satisfactory.

Brantford.—Total number of square yards laid to date of one-course, 2,626. The first concrete pavement laid in 1910 on Lorne Crescent, a residential street. One-course. Length, 394 ft.; width, 24 ft.; depth, 6 ins.

*Abstracted from paper read at the Dominion Good Roads Congress, held in Ottawa, April 10th to 14th, 1917.

Mix, 1 to 6 of pit gravel. Transverse joints every 30 ft., filled with pitch, others with wood strips and a few with neat cement. Longitudinal cracks have developed. Pavement laid late in year and caught by frost. Cost, 80 cents per square yard. Gravel cost 25 cents per cubic yard at pit. No repairs have been necessary. Another one-course pavement laid in 1911 on Chestnut Avenue. Length, 535 ft.; width, 26 ft. This is a residential street, but subject to heavy teaming from gravel pit. Grade, from 1 per cent. to 5 per cent. Depth, 5 ins. Mix, 1 to 5 of crushed gravel. Joints made by pine strips ¼ in. wide at top and at bottom to full depth of pavement. A longitudinal joint left in centre for a length of 110 ft. Longitudinal cracks have developed excepting the part where longitudinal joint left. No repairs necessary. Total number of square yards of two-course, 10,779. A two-course pavement laid on Market Street in 1912 runs from main street to the Victoria Bridge. Length, 200 ft.; width, curb to curb, 40 ft. Grade, from 5 per cent. to 8 per cent. A single track of the street railway curves into double tracks at the main street. Business street at intersection of the two main streets and subject to the heaviest traffic in the city. Base, 4 ins. Mix, 1 to 4 of gravel and broken stone. Top, 2 ins. Mix, 1 to 1½ coarse sand. Corrugations, ½ in. deep left every 4 ins. at right angles to the street. No joints left. Very few cracks except in lower section, where a 30-ft. excavation had been made. No repairs necessary other than re-cutting the corrugations. Cost, $1.25.

Park Avenue.—In 1914 a pavement was laid on this residential street, which is subject to the heavy teaming from the factory district, being the shortest route to the main part of the city. It is 1,532 ft. in length and 27 ft. wide; 5-in. crown. This was a two-course pavement. Depth, 7 ins. Bottom course, 5 ins., composed of 1 part of cement to 4 parts of bank gravel. The top 2 ins. was 1 of cement to 1½ of a coarse sand. Transverse joints left every 30 ft. One-half the width of the pavement for its full length was first constructed; the other half joining it was constructed without any filler between. This pavement has given good satisfaction. Only two or three cracks have developed, and these owing to local conditions. It has cost nothing to repair. Cost, $1.30.

Erie Avenue Pavement.—This is on the continuation of the Cockshutt Road from Brantford township, and is the main street from Eagle Place to the city. This pavement was begun in 1916. Its length is 3,200 ft., of which 1,350 ft. have been completed. Concrete curb and gutter put in before pavement laid. A single track of street railway is laid down the centre of the street. Width from curb to curb, 36 ft. Sub-foundation, gravel. Between ties one-course concrete, 6 ins deep, 1 to 6 of pit gravel. Above ties and between rails one-course 1 to 3½ of pit gravel. Cross-joints every 11 ft. From rails to water table two-course pavement 11 ins. deep at rail and 9 ins. at water table. Bottom course, 1 to 4 of pit gravel. Top course, 2 ins. 1 to 1½ of coarse sand. In bottom course, 1½ ins. of sand between slabs. Joint for top cut through and groover run across. Transverse joints left every 33 ft. Cost per square yard, $1.55, of which 46 per cent. was for material. All the pavements were broomed after being floated. The sand, gravel and broken stone is from the city pits, drawn in Brantford dump wagons. A Brantford Waterous road roller and Goold, Shapley and Muir mixer is used, and the cement used is supplied by the Ontario Portland Cement Company, of this city. Brantford labor alone is employed.

Chatham.—Total number of square yards of two-course, 50,000. Base, 3½ ins. Mix, 1 to 4. Top, 2½ ins. Mix, 1 to 3. Average cost, including grading, $1.30. Number of square yards of two-course, laid in 1916, 19,000. Base, 3½ ins. Mix, 1 to 4. Top, 2½ ins. Mix, 1 to 3. Average cost, including grading, $1.30. Reinforcement used in all pavements except about 2,000 sq. yds. All pavements giving perfect satisfaction except one strip 900 ft. long, laid in 1915. The pavement laid in 1908 was not reinforced and is in good condition. Pavements laid on business and residential streets. First concrete pavement laid in 1908.

Dunnville.—Total number of square yards of one-course, 11,833. Thickness, 6 ins. Mix, 1:2:4 of stone. No reinforcement used. Eighty per cent. free from cracks in 1915. A few holes developed by 1915, but most of it in good condition. Most of it resurfaced 2 ins. with Tarvia at cost of 35 cents per square yard. Pavement laid with intention of resurfacing. On business and residential streets. First concrete pavement laid in 1912.

Grimsby.—Total number of square yards of one-course, 17,500. Thickness, 6 ins. to 8 ins. Mix, 1:2:3. Average cost, 84 cents. No reinforcement used. The road has given every satisfaction. While cracks show on minute examination on 50 per cent. of blocks, no crack is serious or requires attention and in no way affects the road. Low cost partly owing to sand and gravel obtained for cost of hauling, 65 cents per cubic yard. This pavement laid in 1916.

Ingersoll.—Total number of square yards to end of 1915, 4,100. Semi-business and residential streets. One-course, laid in 1915. Depth, 7 ins. Mix, 1:1½:3 crushed stone. Cost, $1.35; where extra grading, $1.50. In 1916 number of square yards laid, 11,122.

Jarvis.—Total number of square yards of one-course, 14,000; thickness, 7 ins. at centre; 5 ins. at sides; mix, 1:2:3 stone. Except in about 300 sq. yds. no reinforcement was used. 25 per cent. of the blocks free from cracks. Cracks attributable to excessive heat and dryness of 1916 and foundation not having been thoroughly consolidated. First concrete pavement laid in 1914.

Kitchener.—Total number of square yards of one-course, 600; thickness, 7 ins.; mix, 1:1½:3 screened gravel; average cost, $1.48. Total number of square yards of two-course, 9,100; base, 5 ins.; mix, 1:2:4 screened gravel; top, 2 ins.; mix, 1:1½:3 stone; average cost, $1.50. Number of square yards laid in 1916 of two-course, 6,040; base, 5 ins.; mix, 1:2:4 screened gravel; top, 2 ins.; mix, 1:1½:3 stone. All the two-course work is reinforced and 99 per cent. of the blocks are free from cracks. Pavement laid on business and residential streets. First concrete pavement laid in 1914.

Kemptville.—Total number of square yards of one-course, 1,682; thickness, 7 ins.; mix, 1:2:3; no reinforcement used; only one lateral and one cross. First concrete pavement laid in 1913.

Leamington.—Total number of square yards of one-course, 36,935; thickness, 6½ ins.; mix, 1:1½:3 gravel or stone; average cost, $1.27. Number of square yards laid in 1916, 25,735; same as above; average cost, $1.25. All pavement reinforced; 99 per cent. of blocks free from cracks. Specifications same as Wayne County. Business and residential streets. Soil, light sandy loam. First concrete pavement laid in 1915.

London.—Total number of square yards of one-course, 19,673; thickness, 5½ ins. at side, 7½ at crown (1913-14); 9 ins. (1915-16); mix, 1:4½ gravel; average cost, $1.60; number of square yards laid in 1916, 4,420 one-course; average cost, $1.66. All pavement reinforced,

24 ins. wide, laid on 4-in. gravel sub-base; crown, 5 ins. Longitudinal joint of ¼ in. Elastite between gutter and curb. Cross-joints of armor plates and ¼-in. elastite, 40 ft. to 50 ft. apart. Heavy clay sub-soil. Tile under curb. Closed to traffic 3 weeks. Cost includes grading (average 18 ins.), sub-base, reinforcing and expansion joints. First concrete pavement laid in 1913.

New Hamburg.—Total number of square yards of two-course, 8,000; base, 5 ins., mix, 1:2:4; top, 2 ins., mix, 1:1½:3, reinforcement used; average cost, $1.41, including grading and engineering. This pavement laid in 1916.

Niagara Falls.—Total number of square yards of one-course, 9,800. In 1913 there was laid 6,500 sq. yds. 7 ins. thick, 1:2:4 mix, costing about $1.47; no reinforcement. In 1915 there was laid 3,300 sq. yds. Width of roadway, 24 ft.; thickness, 6 ins. at sides, 8 ins. at centre; mix, 1:2:3; reinforced with No. 20 Kahm mesh. Expansion joints 35 ft. to 45 ft. apart; ½-in. joints at curb; cost, $1.40, exclusive of engineering, inspection, interest, etc., amounting to 24 per cent. No transverse cracks, 50 per cent. of blocks show slight longitudinal crack near centre which has not opened up. First concrete pavement laid in 1913.

Oshawa.—Total number of square yards to end of 1915, 26,375; business streets; one-course; thickness, 5 ins. at side and 7 ins. at centre; mix, 1:2:4; majority 16 ft. to 18 ft. wide; average cost, including grading, 90c.; no reinforcement used; cost per square yard in 1915, $1 (gravel and sand furnished by town at 10c. per load); let by contract; guaranteed for 2 years. First concrete pavement laid in 1913. Number of square yards laid in 1916, 3,111.

Peterborough.—Total number of square yards of one-course, 975; pavement laid in 1912, 403½ ft. x 21 ft. 9 ins.; mix, 1 to 5 pit run gravel; ½-in. expansion joint in centre at curb and every 25 ft.; cost, 97¾c.; no charge for gravel; hauling included; 95 per cent. of the blocks free from cracks; no heavy traffic, really a lane.

Sarnia.—Total number of square yards of one-course, 10,571; constructed by Ontario Government Highway Department in 1913 on main artery to the town; length, 5,946 ft.; width of concrete, 16 ft. with 4-ft. gravel shoulders on each side; depth, 7 ins.; mix, 1 of cement (10 per cent. of which by volume is hydrated lime) to 4 of gravel. Unit cost per square yard: Grading and ditching, $0.155; mixing lime and cement, $0.084; hydrated lime (29 tons), $0.022; cement (3,462½ bbls.), $0.367; gravel (3,117½ cu. yds.), $0.294; labor on concrete, $0.200; expansion joints, $0.011; drainage, $0.111; gravel shoulders, $0.187; supervision, $0.057; tools and sundries, $0.054; total, $1.542. Men employed, 1 superintendent, 1 working foreman, 1 team delivering cement-lime mixture, 1 man handling cement at mixer, 8 gravel shovellers, 2 men wheeling gravel to mixer, 1 engineer, 1 fireman, 1 man dumping bucket, 2 men shovelling concrete and operating first template, 2 concrete finishers who also operated the box template and set the wooden curbs or concrete forms, 2 extra men for watering concrete, removing forms, greasing expansion joint strips and covering concrete with gravel. The above record is from the Highway Improvement Ontario 1914 Report where full description of the road is given.

Simcoe.—Total number of square yards of one-course, 2,475; thickness, 9 ins. at centre, 6 ins. at gutter; mix, 1:2:3; width, 48 ft.; not reinforced; centre joint. No cracks have developed. Average cost, $1.45, including grading. Laid in 1916.

Sault Ste. Marie.—Total number of square yards of two-course, 19,700; base, 5 ins.; mix, 1:5; top, 2 ins., 1:2 screened gravel fine to ⅓ in.; average cost, $1.37, including grading (without overhead charges). Number of square yards laid in 1916, of two-course, 10,700; same as above. No reinforcement used. First concrete pavement laid in 1914.

Stratford.—Total number of square yards of one-course, 6,400; thickness, 5 ins.; curb, 7 ins. at centre; mix, 1:1½:3 crushed stone; reinforced No. 7 triangular mesh and Kahn joints; 99 per cent. of blocks free from cracks—remarkable considering sub-grade. This pavement laid in 1914.

Stamford.—Total number of square yards of one-course, 2,050; thickness, 6 ins.; mix, 1:2:4; cost, $1.47 (labor 15c. per square yard); no reinforcement used.; 80 per cent. of blocks free from cracks. This pavement laid in 1913.

St. Jacobs.—Total number of square yards of one-course, 4,392; thickness, 7 ins.; mix, 1:4; average cost, 97 cents. Square yards laid in 1916, one-course, 1,777; thickness, 8 ins.; mix, 1:4; no reinforcement. Very few cracks. Makes a good road. First concrete pavement laid in 1913.

St. Thomas.—Total number of square yards of one-course, 22,100; thickness, 7 ins.; mix, 1:1½:3 stone; all reinforced; average cost, $1.50. First concrete pavement laid in 1913. Street car tracks laid in 1914. Sub-grade, 9 ft. wide, 4½ ins. concrete of 1:1½:3 stone, on which ties and rails laid and concreted to top of rails.

Steelton.—Total number of square yards of two-course, 8,866; base, 5 ins., mix, 1:5 gravel; top, 1½ ins., mix, 1:1:1 granite screenings. Laid in 1912.

Toronto.—Total number of square yards laid since 1895, 144,243; number of square yards laid in 1916 of one-course, 2,837; thickness, 6 ins.; mix, 1:1-1½:3; average cost, $2.42. Number of square yards laid in 1916 of two-course, 16,875; base, 4 ins.; mix, 1:1-1½:3; top, 2 ins.; mix, 1:1-1½:3; average cost, $2.07. The first concrete pavement was laid in 1895. Total number of square yards to date in which reinforcement was used, 16,875. The prices quoted include the entire cost involved in laying the pavements, trimming the boulevard, adjustment of walk and all grading on the actual line of the pavement.

Toronto and Hamilton Highway.—162,841 sq. yds laid in 1915; 149,159 sq. yds. laid in 1916; general width of pavement, 18 ft.; spur line near Burlington of 7,323 sq. yds. is 9 ft. wide. In Oakville, about 7,400 sq. yds. is 50 ft. and 30 ft. wide. One-course pavement; mix, 1:1½:3. Coarse aggregate of crushed stone from Dundas quarry. Fine aggregate, a coarse sand. Estimated cost, $1.40 per square yard. The completed cost will be in the neighborhood of that figure. The surface is standing the wear very well. The repairs to cracks and joints on the 1915 work made in 1916 cost $76.71 for material and $200.34 for labor.

Walkerville, Sandwich, Ford City, Sandwich East and Canadian Steel Corporation.—Total number of square yards of one-course, 70,410; thickness, 6½ ins. to 7 ins.; Sandwich East, 6 ins. wide and 8 ins. centre; average cost, $1.25. Number of square yards of two-course, 223,992; base, 4½ ins. to 5 ins.; top, 2 ins.; 7,000 sq. yds., 1½ ins.; average cost, $1.25. Number of square yards of one-course laid in 1916, 7,960; thickness, 7 ins.; mix, 1:1½:3; reinforcement used in all excepting about 13,000 sq. yds. First concrete pavement laid in 1908.

Mr. Owen McKay, M.Can.Soc.C.E., of Walkerville, who was engineer for these pavements, after describing the earlier pavements laid, states he laid more than 4½ miles in 1914 in Sandwich East under the Wayne County specifications. One-course: mix, 1 : 1½ clean, washed gravel; 1½ miles 16 ft. wide and 3 miles 15 ft.; depth, 6 ins. at side, 8 ins. at centre; base filed; expansion steel joints 25 ft. apart. Only 500 lin. ft. to-day found with cracks and so fine as to be scarcely noticeable. No reinforcement used.

In 1915 he laid two lines of pavement for the Canadian Steel Corporation each 3½ miles long with a 25-ft. strip between reserved for street railway. Mix, 1 : 2 : 4. No cracks have appeared excepting in a strip about ¾ of a mile long where drainage imperfect. Mr. McKay concludes where width does not exceed 18 ft. with base flat, sides 6 ins. and centre 8 ins. and expansion joints not more than 30 ft. apart, wire reinforcement may be safely dispensed with providing the sand and gravel are washed and free from impurities and all stones over 2½ ins. in diameter, crushed and used in the above proportions.

Wingham.—Total number of square yards of one-course, 11,448, on main business street of town; length, 2,410 ft.; width, 40 ft.; thickness, 7 ins.; crown, 6 ins.; mix, 1 : 2 : 4. Reinforcement used throughout of No. 9 gauge steel wire, 6-in. x 12-in. mesh. Expansion joints 40 ft. apart; Baker armor plates; cost, $1.35. This pavement laid in 1913. No cracks have developed. Repairs to a few high joints, holes and rough spots caused by frost. In all other respects the pavement has proved entirely satisfactory.

Woodstock.—Total number of square yards of two-course, 13,523 (these laid in 1916); base, 5 ins.; mix, 1 : 2½ : 4; top, 2 ins.; mix, 1 : 1½ : 2½; reinforced by No. 9, 4-in. x 10-in. wire fencing.

Windsor.—To end of 1915 total number of square yards, 346,843; in 1915 number of square yards laid, 18,986; cost per square yard prior to 1915, $1.15; cost per square yard in 1915, $1.35. First concrete pavement laid in 1907. About 45,000 square yards in 1916.

The concrete pavement laid in the 33 places given in this schedule amounts to 1,366,660 sq. yds., of which over 75 per cent. is one-course work. The quantity reported as laid in 1916 is 350,048 sq. yds.

CANADIAN SOCIETY OF CIVIL ENGINEERS, REGINA BRANCH.

At the regular meeting of the Regina branch of the Canadian Society of Civil Engineers, held last Thursday evening, it was unanimously decided to support most heartily the proposal of the council of the parent body in Montreal to present a memorial to Premier Borden on his return to Canada from England, showing the number of large and important Canadian engineering works which have been handled by alien engineers.

Following this, a discussion arose on the proper treatment of W. S. Tye's paper, "Canada's Railway Problem and Its Solution," read before the parent body in Montreal. It was thought by those in attendance that the engineering profession throughout the Dominion does not express its opinion strongly enough on the difficulties of the railway problem facing Canada.

It was decided to call a special meeting of the Regina branch to read Mr. Tye's paper, and discuss this question thoroughly. It was also decided to invite representatives of the provincial government and other public bodies to take part in the discussion of this paper, and to make public the opinion of Saskatchewan engineers.

HOW CANADIAN ENGINEERS ORGANIZE.*

By Professor C. H. McLeod, Ma.E., F.R.S.C.

THE organization of Canadian engineers, from a strictly professional point of view, is comprised in the history and growth of the Canadian Society of Civil Engineers. There are in Canada, of course, a number of societies which are only in part professional, and which do not base their membership test on scientific or technical qualifications. Although these institutions are of importance, they cannot be considered as representative of the profession, and, in fact, Canada may be looked upon as exceptional, in that one corporation is exclusively representative of the engineering profession within its boundaries.

The Canadian Society of Civil Engineers was established by a charter of the Dominion of Canada in 1887 under an old English definition "as having for its objects and purposes to facilitate the acquirement and interchange of professional knowledge among its members, and more particularly to promote the acquisition of that species of knowledge which has special reference to the profession of civil engineering, and further, to encourage investigation in connection with all branches and departments of knowledge connected with the profession."

It will thus be seen that the Canadian Society in its formation was modelled on the lines of the British Institution of Civil Engineers. The majority of the charter members, of whom there were 19, were members of the Institution.

The life conditions, however, of the Canadian Society, representing so vast a territory, were soon found to be quite different from one having to concern itself with the profession in the British Isles, and some considerable additional provisions to the original conceptions regarding it were found to be necessary. Chief amongst these was emphasized the need for auxiliary societies, having headquarters in various centres of the country. In the early years of the Society provision was, therefore, made for the establishment of branch societies. The branches, of which there are now ten in existence, are representative of the Society, and occupy points of vantage at various centres, from the Atlantic to the Pacific Coast. They have, under our constitution, complete freedom of action, and are, in so far as their professional activities are concerned, independent local societies. An intimate corporate relationship, however, exists, and the establishment of a branch at any centre does not release the members of the branch from their obligations to the Society. The members of a branch are the corporate members of the Society residing within 25 miles of the branch headquarters, and such other members as desire to identify themselves therewith. It will be seen that the branch societies are thus sentinels for the central body, of which they are a corporate part. They interest themselves not only in general professional affairs and in the work of the Society as a wohle, but also in local matters of engineering concern, and thus constitute a very important cementing material between the engineering profession as represented by the Society and the public at large.

The financial relations of the branch to the central Society—always a troublesome consideration—have been arranged on a system of rebates of the dues paid by each

*Synopsis of a paper read before the Third Conference, Committee on Engineering Co-operation, at Chicago, March 29th, 1917.

and every member of the branch. In many instances, also, special branch dues are imposed by the branches, so that the revenues of the Society are, in these cases, not tapped to the full extent necessary for the upkeep of the local institutions.

In the endeavor to broaden the professional scope of the Society it was found desirable to establish sections representative of the chief lines in which civil engineering practice divides itself. These we designate as "electrical," "mechanical," "mining," and "general," the latter standing for the work usually understood as comprised under "civil" when used in its narrow sense. Each section has its own chairman and vice-chairman, one or other of whom presides over the professional meetings of his section, which are held at the Montreal headquarters, and both of these officials are supposed to interest themselves in securing suitable papers. Some of the larger branches operate along similar lines and have their own officers of sections. To provide for articles or discussions covering technical work of interest to all sections, monthly Society meetings are held. It thus follows that each of the sections, meeting alternately at fortnightly intervals, has an opportunity of holding two meetings during the winter session.

The professional papers of the Society, which are issued in the form of advance proofs, are promptly distributed to the branches and to the membership at large, and thus become available for discussion by the branch members, as well as by those who assemble at the Montreal meetings.

There are, of course, many matters of interest to Canadian engineers, as, I suppose, to the engineers of all countries, on which opinion is largely divided, and some of these stand out, perhaps, with the most marked prominence in a country such as Canada, covering so large a territory and comprising as it does men of different lineage and divergent attitude of mind. Chiefest amongst such problems is the question of legislative protection, in connection with which we have, as elsewhere, those who do not desire any (however remote) a suggestion of legal control, and those who, on the other hand, would wish to see established the most exclusive protection in the practice of their profession.

It should here be explained that in Canada the Dominion Parliament has no authority over educational or professional affairs, and that, as a consequence, legislative control of professional practice must, if it is desired, be obtained separately in the several provinces. The exponents of the wide-open door are probably those engineers who occupy the important positions, either as consulting practitioners or as the official representatives of large corporations. Those, however, who would limit the practice of engineering by legislative enactment, whether they so express themselves or not, are unquestionably in the majority. This majority desires such protective legislation as is everywhere accorded to the legal and medical professions. In Canada we have what are known as the "Quebec Act" and the "Manitoba Act," both, of course, provincial, and designed to govern the practice of civil engineers. The former has a penalty clause, while the latter has no such governing condition, and is, consequently, inoperative. The Quebec Act, however, in practice permits all members of the Canadian Society of Civil Engineers, whether they become such under the provisions of the act or not, to practice their profession within the province, and hereby there is, fortunately, a safety valve introduced which makes for a smooth running.

That further legislative control of engineering practice in Canada is one of the problems which we shall have to face, and that in the very near future, is, to my mind, beyond peradventure. As an indication that this is a coming event, the Society has recently, under strong pressure, made provision in its by-laws for the establishment of provincial divisions, and already there are such organizations in operation in British Columbia and Alberta. A function of these bodies has clearly to do with controlling legislation, and the object of their establishment would seem to be to gain a vantage point of local knowledge and at the same time to secure the co-operation of the profession throughout the Dominion as represented by the Society. While there undoubtedly exists a considerable range of opinion as to the desirability of a certain form of legislative enactment, there is amongst Canadian engineers a united front as regards the necessity of insistence on advanced educational requirements. In this respect the Society demands an educational test of candidates seeking admission to the grade of associate membership, which is practically equal to the degree standards of an engineering course. It is a pleasure to record that the number of candidates for admission to corporate membership who have not had the advantage of university training is steadily decreasing. In other words, that the scientific training of those young men now entering the profession is, year by year, reaching a higher plane.

GOOD ROADS SYSTEM IN LATIN AMERICA.

Colombia is the latest South American country to work out a comprehensive road system intended to facilitate highway traffic and to connect interior points with railways, ports and commercial centres, says a consular report. Much interest in road construction has been shown recently in the neighboring countries of Venezuela and there is a certain similarity between the completeness of the Peruvian plan and that of the project passed by the Colombian Congress and promulgated in the Diario Oficial of December 22. No provision has been overlooked for the extension of roads over practically the whole of Colombia, as well as for the selection of the best routes, and for the maintenance of the roads when completed. Important measures have been adopted for the financing of this project and for the execution of the plan in all its details.

An annual appropriation of $700,000 is to be included in the national budget for work on these most-needed roads and certain others, nearly one-third of the whole amount to be used for the great central highway of the north. Careful surveys of all proposed roads must be made and the most practicable routes selected, with the approval of the minister of public works, before construction is begun. The government may authorize local boards to construct and maintain roads for which plans and estimates have been made by authorized engineers, under the direction of a bureau of national roads, created by this law.

A manganese mine in Costa Rica began shipping in May, 1916, and is now putting out about 300 tons a month. Preparations are being made for installing an equipment with a capacity of 3,000 to 5,000 tons a month. The port of shipment will be about two miles south of Braxilito, considerably north of the Pacific port of Punta Arenas. The ore is given as averaging 55 per cent. metallic manganese (80 to 83 per cent. manganese dioxide).

Editorial

THE GOOD ROADS CONGRESS.

If the Governor-General, the leader of the opposition and the Minister of Trade and Commerce back up their spoken pledges of co-operation with any tangible support, federal aid to the good roads movement will certainly have been benefitted by the fourth annual Canadian and International Good Roads Congress held last week at Ottawa.

Federal aid is a necessity if any comprehensive scheme of highway development is to be carried out from coast to coast. There are many municipalities in our sparsely populated country where the total assessed value of the municipality would scarcely exceed the cost of the permanent highways that might have to be built through them as a part of any highway scheme. There are hundreds of municipalities whose borrowing power is entirely too small to permit of costly roads unless aided by province or dominion. Maintenance also is partly a national question, as many of these municipalities could not maintain a highway system even if so much as ten mills were to be added to their tax rate.

The Duke of Devonshire was a leader in the good roads movement in England. Not many years ago the two houses of the British Parliament formed a joint committee for the discussion of road problems throughout the United Kingdom, and the Duke of Devonshire was the committee's chairman.

It will be fortunate for the good roads movement in Canada, and fortunate for the future development of this Dominion, if His Highness takes the same interest in Canadian road work that he did in English highway affairs. And what finer or more practical monument could he leave behind in this country, when his term of office will have been completed, than at least the nucleus of a national, transcontinental scheme of highways that will make more readily accessible the farms, the orchards, the ranches, the mines, the industries and the natural glories of Canada?

By interesting the high officials of the government and the opposition, the Ottawa convention probably did more good than any other convention ever held by the Dominion Good Roads Association. Considering the war and attendant circumstances, the congress was most successful. The attendance was not so large as at some former meetings, but it was more enthusiastic and more earnest, and the discussions were probably better than ever before.

Mr. Duchastel and Mr. McNamee are to be congratulated upon succeeding in holding the congress at all this year. Mr. McNamee, the secretary of the association, has been one of the most untiring good roads workers in the Dominion, and the movement owes a great deal to his initiative, foresight and ability. Mr. Duchastel made an excellent president. He ran the meetings in a most businesslike manner, keeping the discussions well in hand yet bringing out all valuable points, and his re-election to the presidency of the association was well-merited.

The chief reason for Mr. Duchastel's re-election as president, however, was to permit him to finish the work of incorporation of the association. At present the Dominion Good Roads Association is largely a myth. It has officers and directors but no roll of membership, no by-laws, no official prestige and no legal existence. It has "carried on" entirely on good-will—largely the good-will of the manufacturers who have most generously supported the exhibitions, often at very great cost.

This condition of affairs could not continue. The number of exhibitors and the size of the exhibits appeared to decrease each year. This year there was almost the irreducible minimum of exhibits despite the efficient and energetic work of Mr. Leach, the superintendent of the exhibition. It was seen that some other mode of support would have to be found if the congress were to be continued. It was decided, therefore, to incorporate the association under Dominion charter, and to have a paid membership list.

Fees will probably range from $1 a year for ordinary members to $100 a year for manufacturing members. This will distribute the cost of the propaganda more equitably and will give everyone a chance to pay toward the good work, making the congresses more independent of the support of exhibiting manufacturers.

It is expected that the new association will in time have a permanent staff of secretaries who will be able to carry on the work steadily and consistently, probably devoting their whole time to it. The province of Quebec has promised an annual grant to the association, and it is presumed that Ontario and other provincial governments will make similar grants.

CHEMISTRY IN ENGINEERING.

Slowly but surely the field of the chemist is commingling with many branches of the engineering profession. Since war broke out the science of chemistry has more nearly come into its own as a factor in engineering work. With the possible exception of mathematics and physics, the science of chemistry stands closest to engineering, and as the manufacture of materials used in engineering approaches perfection, the more pronounced becomes the handiwork of the chemist.

The production of iron, steel and the alloys for varied and special purposes serve as examples. The constituents of each of these are selected in percentage by the chemist, and the rules of thumb are no more. The chemist furnishes the data by which the engineer varies the chemical content of his materials to obtain the particular physical characteristics desired. The manufacture of cement is another striking example of the important part played by the chemist in relation to engineering.

In the realm of water supply and sewage treatment the position of the chemist is a most important one. What he finds in the nature and extent of impurities determines the policy of the engineer in the methods to be adopted so far as treatment of the water supply is concerned. The utilization of nitrogen, ozone or chlorine to destroy bacteria, the introduction of copper sulphate to dispose of algae,—these are instances in which the sanitary engineer, at least, is dependent upon the chemist.

In the province of highway work, too, the chemist comes into close contact with the engineer. In the

selection and composition of the materials of construction and in the disposal of waste, a knowledge of chemistry is essential to the engineer. The results of engineering skill supplemented by expert assistance from the professional chemist, leads to the belief that the advancement of industry would be relieved of a considerable amount of its hazard if there were more outward acknowledgment of the interdependence of these two sciences.

PERSONAL.

C. CHAS. LAPIERRE, of the roads engineering department of the Canada Cement Co., Limited, has resigned to organize the Quebec Cement Co., Limited.

E. HUBBARD has been appointed town engineer of Bridgeburg, Ont., owing to the resignation of CARLTON MILLER, who was recently named to succeed EDWIN J. JUKES.

E. T. McLAREN, assistant city engineer of Brantford, Ont., who has enlisted in the Canadian Engineers, for overseas service, has been granted leave of absence by the city council.

C. N. SCHRAG, sales engineer of the Ontario District Office of Canadian Allis-Chalmers, Limited, has resigned to become general sales manager of the Bawden Machine Co., Limited, Toronto.

Prof. JOHN C. McLENNAN, of the University of Toronto, and a member of the Advisory Council on Industrial and Scientific Research, has been appointed to the British Board of Inventions and Research.

CHARLES H. WAYBRANT, who for the past six years has been with the Steel Company of Canada, at the Toronto office, has joined the staff of Baines & Peckover, iron and steel merchants, 98 Esplanade E., Toronto.

GEO. H. OLNEY, managing director and treasurer of the Eugene Phillips Electrical Works, Limited, Montreal, has, on the advice of his medical advisors, severed his active connection with the company. Mr. Olney took over the business eighteen years ago when it was comparatively small. Under his care the company has developed until to-day it is in size among the first half dozen of the insulated wire and cable manufacturers on this continent.

J. A JAMIESON, M.Can.Soc.C.E., Montreal, was struck by a street car in Westmount a couple of weeks ago and was very severely injured. He was either unconscious or only partly conscious for about ten days, but is now out of danger and recovering rapidly. Mr. Jamieson was on his way to the Westmount library at the time, the accident happening near his home. Mr. Jamieson is one of the best-known consulting engineers in Montreal, having specialized largely in reinforced concrete construction. He is perhaps best known in elevator construction work on account of his investigations in regard to grain pressures. He was consulting engineer to the city at the time of the Montreal aqueduct break, and it was his investigations in regard to that accident that finally led to the protests by Montreal engineers against the aqueduct power scheme being carried on as planned.

OBITUARY.

Hon. Sir LYMAN MELVIN-JONES, president and general manager of the Massey-Harris Co., Toronto, died on April 15th from diabetes following two operations. Sir Lyman was 74 years of age and had been critically ill for many months.

JAMES BALFOUR, a well-known architect of Hamilton, Ont., passed away recently at the age of 64 years following an illness which confined him to his home for some time. Under his supervision the city hall in Hamilton was erected in 1886-89.

J. D. CAMERON, railway contractor, passed away at his home in Toronto on April 8th at the age of 77 years. The deceased was born in Ottawa, and removed to Toronto four years ago. He was concerned in the building of the Intercolonial and Lake St. John Railways.

Flight Lieut. STANLEY JAMES PEPLER, of Toronto, who in the casualty list of March 12 was reported missing, has now been reported killed, fighting at odds against two German air craft. He was 26 years of age, and a graduate of the School of Practical Science. When war broke out he was assistant engineer with the Harbor Commission.

HENRY SKEFFINGTON POOLE, M.Can.Soc. C.E., died at his home at Guildford, Surrey, England, recently at the age of 72. He was for many years manager of the well-known Acadia Coal Co. Mr. Poole was one of the charter members of the Canadian Society of Civil Engineers, and served on the council of the Society in 1887, 1888, 1893 and 1901.

HENRY A. EVERETT, at one time electrical engineer of the Montreal Street Railway Company, died recently at Pasadena, California. Mr. Everett superintended the conversion of the horse cars into electric driven cars in Montreal. Subsequently he was president of the London Street Railway Co., London, Ont., the Toledo Railways and Light Co., the Cleveland Railways Co., and was financially interested in many other tram companies in the United States.

Lieut.-Col. E. WOODMAN LEONARD, D.C.M., commanding the 3rd Brigade, Canadian Field Artillery, has been killed in action. He was a member of the firm of E. Leonard & Sons, London, Ont., of which firm his father, Mr. F. E. Leonard, is manager. He went overseas in the fall of 1914, and has been on duty ever since. In the first battle of Ypres Major Leonard's generalship stood the crucial test. He was decorated with the D. C. M. and promoted to a lieutenant-colonelcy.

JOHN J. DRUMMOND, of Midland, Ont., died at the home of his brother, George E. Drummond, in Montreal, on Saturday, April 7. Mr. Drummond was long identified with the development of the iron and steel industry in Canada. In association with his brothers, George E. and the late T. J. Drummond, he established iron furnaces at Radnor, Quebec, and opened up large iron properties in the Maritime Provinces. He was president of the Zenith Machine Co., Midland, Ont. The deceased was born in the North of Ireland in 1856 and came to Canada at an early age.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, TORONTO SECTION.

The annual meeting of the Toronto Section of the American Institute of Electrical Engineers will be held in the Engineers' Club lecture room, 90 King Street W., on Friday, April 20th, at 8 p.m. There will be presented to the meeting a report of the chairman and a short report of the secretary.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

ECONOMICAL DEVICES IN CRIBWORK CONSTRUCTION

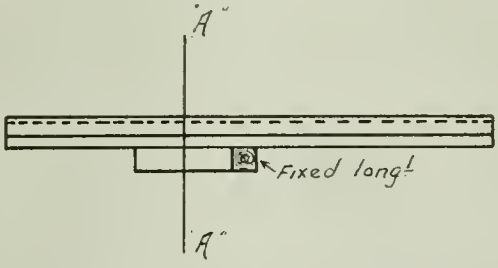
DETAILS OF CONSTRUCTION OF SKIDWAY USED IN CONNECTION WITH BUILDING OF CRIBS UP TO FIFTY FEET IN LENGTH

By A. E. EASTMAN, A.M.Can.Soc.C.E.

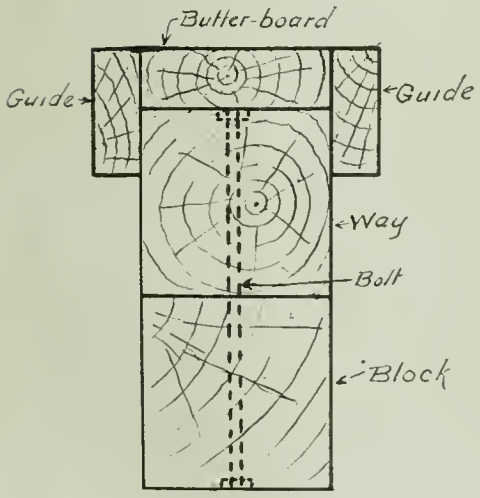
IN the following article the writer does not attempt to advance, perhaps, anything new, or claim to be the originator of any of the devices described. He is of the opinion, from observation during his experience, that it often proves that some cheap, easily built and easily maintained device will save its value, or cost, to a contractor many times for certain work. Hence these notes. The devices described will be seen to be chiefly applicable to cribwork. No attempt has been made to give fixed dimensions, but each case would have to be governed by existing circumstances.

Fig. 1 gives the general plan and necessary details for a skidway or ways on which may be built light cribs up to, say, fifty feet long. In the particular case where this style was used the ways were located on a canal bank, and the crib was forty feet long. The longitudinal or under timber was 12 in. by 12 in., solidly blocked up to the required height, and made level throughout its length. The ways were of the same size timber. Under each way and just back of where it rested on the longitudinal, another piece of 12 in. by 12 in., from three to five feet long, was securely bolted to the way, the object of this being that, when the crib was launched, the ways would not go into the water, but be held by this block. The ways were not fastened to the longitudinal.

On these ways were placed the "butter-boards." These boards were 4 in. by 12 in. plank, with a piece of 3 in. by 8 in. securely bolted to each side to act as guides to keep the "butter-boards" straight on the ways during launching, and thus assist in keeping one end of the crib from going too fast. As a lubricant between ways and "butter-boards" a mixture of tallow and oil was used and placed before starting a crib.

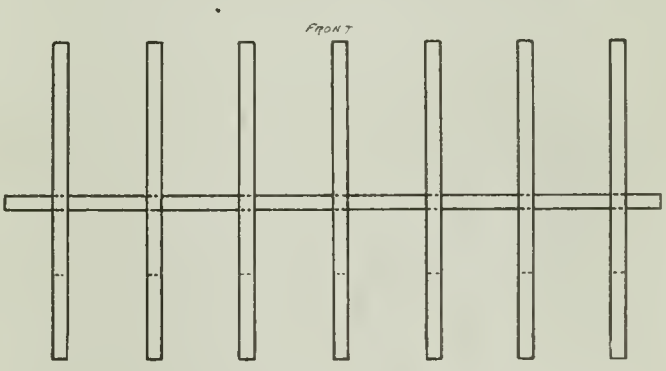


END ELEVATION



ENLARGED SEC. THROUGH "AA"

LONGITUDINAL ELEVATION



PLAN Butter-boards removed

Fig. 1.—Ways on which to construct short cribs.

The "butter-boards" being in position, a crib was begun, the bottom being made to conform to the dredged crib-seat as determined by soundings, blocking being placed, where necessary, between the lower courses and the "butter-boards." Care was taken to keep the centre of gravity of the crib back of the longitudinal, but as

near it as possible, consistent with danger of premature launching. When the crib was built to the required height, the rear ends of the ways were raised by using planks as levers, and the crib slid easily into the water. As soon as the crib was afloat the ways dropped back into approximate position. All that was necessary was to get the "butter-boards" from beneath the crib launched and place them. The writer saw a number of cribs launched from these ways, and the operation of launching and getting ready for the next crib took but a few minutes in each case, and no mishap occurred at any time.

Fig. 2 shows the general plans and enlarged section of important details of a type of ways for heavier cribs than the one just described. This type would do equally well for small cribs, but would cost more to build, and this first cost might not be warranted.

The longitudinal in this case would be, say, 12 in. by 12., or, in some cases, 15 in. by 15 in. would be better. This longitudinal would, of course, be made solid and level throughout. At the required intervals along this longitudinal, where the ways would be placed, the longitudinal was gained down to 12 in. or 15 in. round, depending on the original size of the timber. Each way was made of two 12 in. by 12 in. timbers, each with a semicircular notch about the centre. These two timbers were bolted together, one above and one below the longitudinal as shown, allowing the gain in the longitudinal to work freely in the notches in the ways.

The crib was then built directly on the ways and the ways greased at the time of launching, or "butter-boards" could have been used similar to the ones previously described. The author prefers the use of the "butter-boards." After the launching the ways would drop back into correct position for the next crib.

Occasionally, when cribs are to be built of square timber, the timber is carried to the site by boat and unloaded into the water and boomed until used. In such cases the timbers are taken from the water as wanted by a derrick or by skids and ropes, this last method being somewhat expensive. The derrick must either be of the floating type or fixed, with the usual guys. The latter type has

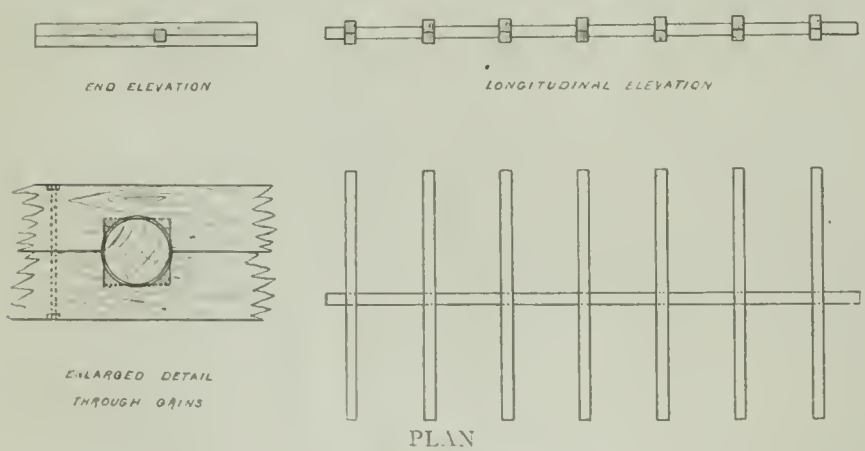


Fig. 2.—Ways for larger cribs.

the disadvantage of being fixed, and materials, etc., must be brought to it. The work sometimes will not warrant a large steam-operated floating derrick.

Fig 3 shows the plan and elevation of a small hand-operated floating derrick, easily built, cheap in construction and operation, costing nothing when not in use, and easily moved about the work as required.

A stout raft, of size according to the sticks to be lifted, is built of 12 in. by 12 in., or any suitable sized material, and decked where necessary. Merely spiking the decking to the timbers would construct the raft.

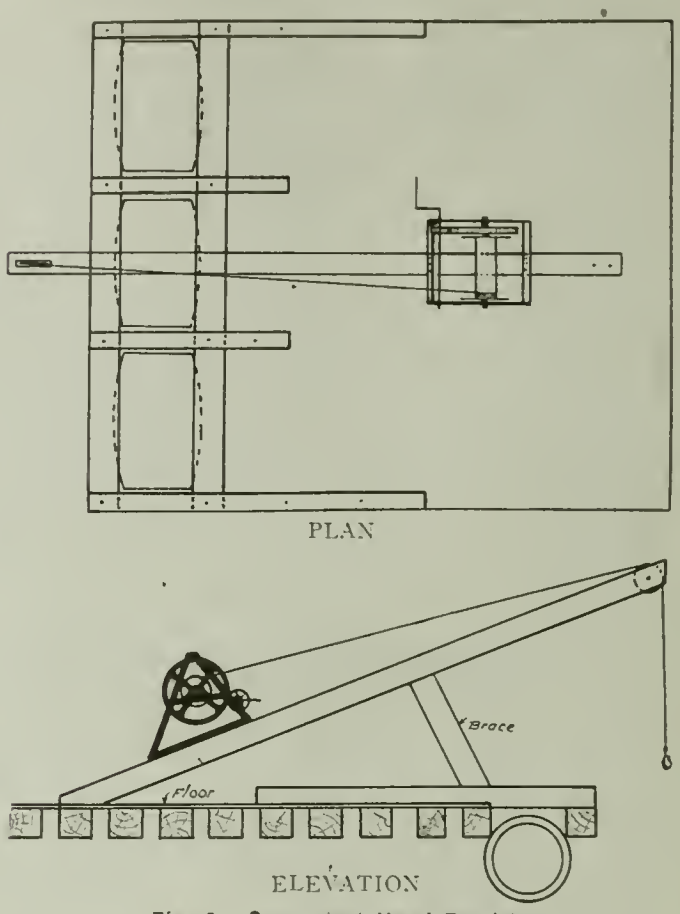


Fig. 3.—Convenient Hand Derrick.

Near one end a space of about a foot and a half is left between the timbers undecked, and in this space are placed a number of wooden oil or other barrels, held wholly or partially under water by the timbers to give additional buoyancy to the raft at that end. Care must be taken that these barrels are kept water-tight or the whole advantage is lost.

A sloping beam or boom is then fastened to the raft, the outer end extending over and beyond the barrels, and sufficiently high to lift a stick to the crib being built. The other end is securely bolted to the raft. Supports are placed under where necessary, also guys to the raft corners if required.

An ordinary hand winch is mounted near the inner end of the boom, and a wire cable run from it through a sheeve in the outer end of the boom and terminating in a hook, to which may be attached the timber hooks.

This derrick would prove useful either where cribs are started on ways and launched, or where cribs are built entirely afloat.

Quite frequently tie rods or bolts of up to three inches in diameter are required to be driven in cribwork or docks at about water line. Holes for these are bored, but the contractor is not allowed to make these holes much larger

than the rod or bolt to be driven. As a consequence, there is much discomfort to men driving them from the splashing that is usually unavoidable. The writer watched a gang of men driving short tie-rods at water line, easily, effectively and in comfort. In placing and starting the rods a raft of 12 in. by 12 in. timbers had been used to work from. After the rod had been started the men fastened one end of the raft loosely to the cribwork and used this fastening as a sort of hinge. One man on the raft pushed the free end away from the crib by a pole, and the rest by means of a rope pulled it back again, striking the bolt and driving it home. A more effective blow was delivered than could be done by a sledge, and it was more comfortable to the men.

CORRECTION OF ALIGNMENTS AND GRADES IN EXISTING HIGHWAYS.*

By A. Fraser, A.M.Can.Soc.C.E.,
Engineer, Department of Roads, Quebec.

THE importance of the alignments and grades is very apparent to all engineers who have had to do with the building of roads. When making a special study of this question I was impressed at first sight from the variety in the details of the many opinions expressed and the practices followed. But, after a careful examination of each particular case, I soon found that such variety has been mostly the result of the special circumstances in accordance with which the many aspects of the question have been dealt with and the various problems solved.

The methods used in the construction of roads vary to a certain extent according to the political, economical, commercial, topographical and climatic conditions of each country and the different periods of history. For instance, the famous Roman roads were, as a rule, laid out in approximately straight lines. Mountains, hills and valleys were crossed almost without any regard to topography. Hills were cut through and deep ravines filled in. But everybody will agree that the economical and political conditions of that time were quite different from those which we have to contend with to-day and it would be absurd to attempt to follow their example.

I will confine myself to a brief discussion of the question from the point of view of the construction of our trunk roads in the province of Quebec, setting aside the special conditions in mountainous country.

In the province of Quebec, as well as in all the other provinces, as those trunk roads have mostly to go across agricultural districts, settled many years ago, they have to follow the existing roads.

The engineer who has to secure the best alignments must always keep in mind that as those trunk roads are specially destined to promote agricultural development and the material welfare of the country through which they go, they will also have to bear an ever-increasing automobile traffic. Everybody knows that a great many of the automobile accidents are due to bad alignments. Of course, we cannot make our roads "fool-proof," but the country people and the careful tourist, unfamiliar with the road, have a right to protection against the speed lunatics who drive at from 40 to 60 miles per hour.

No hard and fast rules can be laid down about the alignments and grades. Although I will try to give the general principles which I have by experience found the most practical and important.

The curves should be planned to afford a sight distance; that is, the greatest distance at which the drivers of two approaching vehicles may see each other's machine—of not less than 250 feet. This is the most important rule. I might say that the whole question of alignment and grade is a question of the line of sight of unobstructed vision

Radius of Curvature.—In the province of Quebec, we have adopted the minimum radius of 300 feet wherever possible without incurring a prohibitive cost. If we have to shorten that radius to 150 feet and under, we put danger signs at 400 feet from the B.C. and the E.C.

The pavement itself should be widened in the curves and banked. For the widening, I found the following formulæ, given by Byrne, very useful:

$$R' = \sqrt{\left[R + \frac{W + w}{\frac{1}{2}}\right]^2 + l^2}$$

R' = minimum radius of outer curve.
R = radius of the inner curve of the road.
W = width of road on tangent.
w = total width of vehicles.
l = total length of vehicles, including teams.

For the banking of the curves, the following rules are advisable: On a curve of between 2,000 and 800 feet radius the outer side of the pavement should be 6 inches higher than the inside one; between 800 and 550 feet radius, 7 inches; between 550 and 400 feet, 8 inches; between 400 and 300 feet, 9 inches; and under 300 feet, 10 inches.

When a curve occurs on an ascent, the grade at that place must be diminished in order to compensate for the additional resistance of the curve. When it is necessary to make a radius of curvature less than 300 feet, we usually follow the principle of reducing the grade on the curve at the rate of one per cent. for every 50 feet that the radius has to be reduced; so that where we are locating a five per cent. grade and have to put in a curve with 200 feet radius, we give a three per cent. grade.

As a rule, there ought to be a tangent of about 100 feet between two curves. Quick reverse curves are disagreeable and dangerous with automobile traffic and are to be avoided.

To cross all obstacles as nearly as possible at right angles. The cost of skew structures increases nearly as the square of the secant of the obliquity.

The road on each side of an obstacle should be straight on a length of at least 50 feet when there is a possibility of doing so without incurring prohibitive expenses.

Do not overestimate the advantage of straightness. The curved road around a hill is often no longer than the straight road over it. In addition, a more or less sinuous course is an advantage from a maintenance standpoint, as on a winding road the wheel traffic has a tendency to spread over the entire surface.

Carry the road along the southern or western slope of ridges, if possible, so that it may be less exposed to storms and dry out more quickly after heavy rains and the melting of snow.

The difference in the length between a straight road and one which is slightly curved is very small. On the Montreal-Quebec Road, we have eliminated all the bad curves wherever possible and through that fact we have reduced the first 50 miles of roads from Montreal by only 400 feet. As a matter of fact, we generally follow the

*Abstracted from paper read before the 4th Canadian and International Roads Congress, Ottawa, April 10-14, 1917.

line of the old roads as long as there is no bad curve and no danger for the automobile traffic.

The maximum grade on our trunk roads is five per cent., and the exceptions to this rule are very few. It has been demonstrated by careful observers that a horse, for a limited period of time, can exert 40 per cent. of his weight in tractive force; then, for a short distance, it is better to place a 6 or 7 per cent. grade over a limited distance than to make a deep and expensive cut.

In the province of Quebec we generally make the grade follow the natural undulations of the ground as long as we remain below the maximum grade and the sight distance is at least 250 feet. The expenses incurred in making a level or nearly level road would not be warranted by the traffic anticipated for many years to come. Farmers are satisfied with a maximum grade of 5 per cent. and this grade meets with no objection from owners of motor vehicles of any type. Some experiments made by Mr. H. Kerr Thomas and Mr. O. Ferguson, of Buffalo, New York, for the Pierce Arrow Motor Co., show that the class and kind of surface exert more influence upon the motor vehicle than the per cent. of grade and that it requires practically the same tractive force on a one per-cent. grade in sand and loose stone to handle the same load as it does on a 27 per cent. grade on concrete.

A farmer or teamster would rather go up a mile of 5 per cent. grade on a good alignment than a mile and a half of curves on a 2 or 3 per cent. grade, with a possible surprise party awaiting him at every turn of the road. It is generally admitted that an automobile of ordinary power can operate on high gear wherever the grades do not exceed 5 per cent.

Grades as high as 10 per cent. or over must be avoided at all cost in our country because they are very dangerous, both for horse and motor traffic in frozen and icy weather.

Deep cuts must be avoided as much as possible on account of the snow and the resulting difficulties for traffic in winter and spring.

There is occasionally a road upon which the summit of two intersecting grades is a source of danger, because the drivers of cars which happen to meet just at the top cannot see each other until just before they meet. This meeting point of two grades should be rounded off by a vertical curve so as to insure a sight distance of at least 250 feet.

One of the most important questions that we have to take care of in determining the grades and the alignments is that of drainage.

Drainage is the most important factor in the construction of roads and we cannot get proper drainage if the road has not been properly located.

To summarize, I might say that we must correct the alignments and grades so as to insure a good drainage and eliminate all dangers where possible.

At a time well within the memory of most road builders, the element of safety commanded relatively little attention in road work. Neither in design nor in construction was a safe road kept in mind as the kind to be built, and little effort was made to eliminate danger points in existing roads. The road builders of that time were not greatly at fault on account of the traffic which was rather a slow traffic. As the automobile evolved from a curiosity to an everyday business and pleasure, conditions have changed. And, in the future if our successors find some defects in the roads that we are improving to-day we will have deserved their criticism.

It is contended by those who advocate the construction of relatively permanent surfaces for country roads that such pavements will have a considerable value as foundations for other pavements after the expiration of their life as a wearing surface. This is undoubtedly true if the alignment and grades on the highway are satisfactory at that time. Otherwise, the old pavement will constitute a liability rather than an asset. May not, then, the added cost of right-of-way and grading necessary to make the location the best obtainable be offset to some degree by the value of the old pavement at the expiration of its life?

ROAD OILS AND TARS.*

By Arthur H. Blanchard, M.Can.Soc.C.E.,
Consulting Highway Engineer, New York City.

ROAD oils and tars will be considered from the standpoint of their use in connection with the maintenance of broken stone and gravel roads. Dust laying, as the primary object of the use of oils and tars will not be discussed, as it is believed that special attention, at the present time, should be devoted to such methods of using these materials as will economically preserve the surface of the roads and also render them practically dustless. As the subject will be presented with a view to general adaptability of conclusions and recommendations, it is evident that only conservative practice can be advocated. Local conditions, however, must always be given great weight in the final determination of the method and material to be used.

Definition.—Before proceeding with the discussion of the construction of bituminous surfaces, it is advisable, in order to avoid misunderstandings, to quote the definition of bituminous surface as recommended by the special committee on "Materials for Road Construction" of the American Society of Civil Engineers: Bituminous Surface—A superficial coat of bituminous material, with or without the addition of stone or slag chips, gravel, sand, or material of similar character.

Development.—Since the formulation of the fundamental principles of the successful construction of tar surfaces by the engineers of the Department of Roads and Bridges of France, in 1903, bituminous surfaces have been used extensively in Europe. As an illustration may be cited the construction of 5,000,000 square yards of tar surfaces in a single county of England in 1911 under the supervision of H. P. Maybury, at that time county surveyor of Kent. During the past ten years, American engineers have used bituminous materials in this manner as a standard method for the maintenance of roads and pavements.

Bituminous Materials.—Considerable development has taken place in the use of different kinds of bituminous materials. Tars, of both water-gas and coal-gas types, continue to be used to a large extent. During the past two years an asphalt cut-back with naphtha has been successfully employed in the construction of bituminous surfaces. Oils are not advocated for general use in the construction of bituminous surfaces for the following reasons: (1) Medium and heavy oils generally require considerable time in which to set up; (2) most petroleum products, while in a fluid state, act to a certain extent as lubricants; (3) it is therefore evident that more or less movement of the roadway surface will take place under traffic during the setting-up period; (4) the bituminous

*Presented before the Fourth Canadian and International Roads Congress, Ottawa, Canada, on April 13th, 1917.

mats or carpets formed invariably become wavy and full of humps and ruts under heavy traffic; (5) due to the character of the resulting surface further maintenance is rendered difficult and costly; (6) prior to the re-treatment of oil-coated roads, it is often necessary to remove considerable portions of the bituminous mats with picks and shovels or with scarifiers.

Specifications Covering Bituminous Materials.—The following specifications for refined tars, used hot, and cut-back asphalt for surface treatments have given satisfactory results:—

Water-gas Tar—(1) The refined tar shall be homogeneous, free from water and shall not foam when heated to 121° C. (250° F.).

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.140 nor more than 1.160.

(3) When tested by means of the New York Testing Laboratory float apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 45 seconds nor more than 65 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 96.0 per cent. and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 30.0 per cent. shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause 5 shall be not more than 75° C. (167° F.).

Coal Tar—(1) The refined tar shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.).

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.170 nor more than 1.230.

(3) When tested by means of the New York Testing Laboratory float apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 40 seconds nor more than 100 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 82.0 per cent. nor more than 95.0 per cent., and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 25.0 per cent. shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause 5 shall be not more than 75° C. (167° F.).

Cut-back Asphalt (Philadelphia Specification)—The material shall be a cut-back asphalt prepared in a still by compounding approximately 35 per cent. of a distillate meeting Specification "A" and 65 per cent. of an asphalt meeting Specification "B."

Specification "A"—Beaume gravity, 53 to 60; end-point of distillation, 350° F.

Specification "B"—Specific gravity, 77° F., 1.02 (minimum). Penetration, 100 grams for 5 seconds at 77° F., 85 to 100. Loss 50 grams, 5 hours, 325° F., not more than 3 per cent. Soluble in carbon bisulphide, not less than 99 per cent. Soluble in carbon tetrachloride, not less than 99½ per cent. Ductility (Dow method) at 77° F., not less than 45 cm.

The cut-back asphalt made from a combination of the above two products shall conform to the following tests: Specific gravity, 0.900 (minimum). Penetration of residue after heating for 5 hours 325° F., from 35 to 45. Viscosity, 50 c.c., at 77° F., in Engler viscosimeter, 275 to 350 seconds. Distillate off below 300° C. shall show a gravity of 53 to 60 Beaume. Ductility of residue (Dow method) not less than 30 cm.

Methods of Construction.—In the case of broken stone and gravel roads, the most efficient method of procedure is to clean the surface thoroughly by sweeping with hand brooms, or horse sweepers and hand brooms, the final sweeping being done with bass or other fine-fibre brooms. The bituminous material, which is used both cold and hot, is applied to the surface in amounts varying from ¼ to ½ gallon per square yard, with the aid of pouring cans, hose attached to tanks, hand-drawn gravity distributors, horse-drawn or motor-truck gravity or pressure distributors. Some kind of mineral coating is generally applied to cover the bituminous material. The degree of cleanliness of the surface obtained by sweeping will depend to a large extent upon the details of the original construction. It has been found that a road with a thoroughly rolled and well-puddled broken-stone wearing surface, composed of road metal from 1 inch to 2½ inches in longest dimension may be easily cleaned, and the essential adhesion of the bituminous surface readily secured. This method is characteristic of the modern practice of many of the foremost English and French engineers.

Specifications Covering Construction.—As an illustration of the method of covering essential details of construction of bituminous surfaces with hot tar, the following specifications for certain local conditions are cited.

Heating Refined Tar.—The refined tar shall be heated in kettles or tanks so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed by the engineer to a temperature between 93° C. (200° F.) and 121° C. (250° F.). All refined tar heated beyond 121° C. (250° F.) shall be rejected. No tar shall be heated in kettles or tanks containing any oil or asphalt cement. The contractor shall provide a sufficient number of accurate, efficient, stationary thermometers for determining the temperature of the refined tar in kettles or tanks.

Preparation of Surface of Road.—All sections of broken stone roadways containing depressions, pot-holes, waves, ruts or other irregularities shall be repaired as directed by the engineer, prior to the final preparation of the road for the construction of the bituminous surface, by the use of broken stone which will pass over a one-half (½) inch screen and through a one and one-half (1½) inch screen, stone screenings passing a one-quarter (¼) inch screen, and water, which materials shall be thoroughly compacted by tamping or rolling. Prior to the application of the refined tar, the surface of the broken-stone road, when thoroughly dry, shall be swept clean of all dust, dirt or other loose material by using, first, stiff fibre hand brooms or a horse-drawn stiff fibre sweeper and, second, bass or other fine fibre brooms, as directed by the engineer. When the cleaning is completed the upper surface of broken stone shall be exposed, forming a clean mosaic surface.

Application of Refined Tar.—After the surface shall have been cleaned to the satisfaction of the engineer, and when thoroughly dry, the refined tar shall be uniformly applied over the prepared surface of the road by means of a pressure distributor as hereinafter specified and in accordance with the directions of the engineer. The refined tar, when applied, shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of refined tar to be used in the construction of the bituminous surface shall be applied in one application and shall not be less than 0.35 nor more than 0.45 gallons per square yard, the precise quantity being determined by the engineer.

Pressure Distributor.—The pressure distributor employed shall be so designed and operated as to distribute the refined tar specified uniformly under a pressure of not less than twenty (20) pounds nor more than seventy-five (75) pounds per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationary thermometer in the tank containing the refined tar and with an accurate pressure gauge so located as to be easily observed by the engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the refined tar will be at once shut off. It shall be so designed that the normal width of application shall be not less than six (6) feet and so that it will be possible on either side of the machine to apply widths of not more than two (2) feet.

Application of Broken Stone Chips.—Immediately after the application of the refined tar, a layer, between twelve (12) and fifteen (15) pounds per square yard, of broken stone chips, which will pass through a one-half ($\frac{1}{2}$) inch screen and over a one-quarter ($\frac{1}{4}$) inch screen, shall be spread and broomed as directed by the engineer over the surface of the refined tar and shall be at once rolled as directed by the engineer with a roller weighing between five (5) and twelve (12) tons.

Interruption of Traffic.—In cases where the entire roadway cannot be closed to traffic during the construction of the bituminous surface, only one-half of the roadway surface shall, at one time, be closed to traffic while the bituminous surface is being constructed thereon. The bituminous surface shall not be subjected to traffic until after the covering of broken stone chips has been rolled.

Seasonal and Weather Limitations.—No refined tar shall be applied when the air temperature in the shade is below 10° C. (50° F.), except by the written permission of the engineer.

Failures of Bituminous Surfaces.—The causes of failure of bituminous surfaces are numerous. They may be considered from the standpoint of the condition and character of the original surface, the material used, the method of construction, and local conditions.

The failure of bituminous surfaces from the standpoint of the character of the original surface is many times due to failure on the part of those in charge to place the surface in satisfactory condition before the application of the bituminous material. Many cases are noted where bituminous materials are applied over a surface in which are found many pot-holes and ruts, or which is dirty, due either to accumulated dust and dirt or to the original method of construction. In many cases a damp condition of the surface has resulted in failure.

From the standpoint of the physical and chemical properties of the material, many instances may be cited in which failure is due to materials not having the proper characteristics for the conditions under which they are employed. The large percentage of volatile constituents contained in certain asphaltic oils has rendered surfaces constructed with them unsatisfactory because of the long period required for these surfaces to set up so that the bituminous material will not track or the carpet thus formed will not creep and form waves and humps. In certain cases the use of light oils on tar or asphalt surfaces has softened the original bituminous surface to such an extent as to render the road or pavement unsatisfactory for use.

From the standpoint of construction, failures are due both to the use of too small an amount of the bituminous material and to an excess of material. Improper application, resulting in uneven distribution, is accountable for many failures of bituminous surfaces, while in other cases a lack of sufficient covering of stone chips or material of a similar character has rendered the surface sticky and mushy.

There are numerous instances where bituminous surfaces have been adopted under conditions which call for the construction of bituminous concrete pavements or even some type of block pavements. A mat type of construction, which has been employed to a considerable extent, has proved inefficacious in cases where the amount of motor-car traffic was not sufficient to iron out satisfactorily the caulk holes caused by the horse-drawn vehicular traffic.

ROAD FOUNDATIONS AND DRAINS.*

By R. Crawford-Muir, A.M.Inst.C.E., A.M.Can.Soc.C.E.
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THE first problem in road construction is the location and gradient, but in connection with the travelled surface the chief factors are the drainage and the foundation. Drainage is so closely allied to foundations that it is difficult to speak of one without taking the other into consideration.

Too much cannot be said of the importance of drainage. It is important in connection with any class of road construction.

The drainage of roadways is of two kinds, viz., surface and subsurface. The first provides for the speedy removal of all water falling on the surface of the road. The second provides for the removal of the underground water found in the body of the road, a thorough removal of which is of the utmost importance and essential to the life of the road surfacing.

Subsurface, or underdrainage, is not always required, but in seepy ground is a necessity; a road with a subsoil of a sandy or gravelly nature underdrainage is not required. On the other hand, a clay soil which readily retains water will become almost impassable unless properly drained. In low places, where the water settles at the side of the road, keeping the subsoil constantly saturated, subdrains will effect a marked improvement. Springs on hillsides, which, unless led from the road by drains, will soften the soil, with a consequent failure of the surface at these points. Quicksands have absolutely no supporting power, but if properly underdrained they may serve as a suitable foundation.

A road cannot be maintained in wet ground. Sometimes blind drains will carry off the water. At other times it may be necessary to lay longitudinal or transverse tile drains. Blind drains are not as efficient as tiling on account of their liability to become partially clogged by silt.

*Paper read before the Third Annual Conference on Road Construction. Toronto, March 27th to 30th, 1917.

Side ditches, if properly constructed, often will drain a damp roadbed. These ditches play an important part and must be looked after at all times. Even when underdrainage is not needed, good side ditches are always required. Ordinarily, they need not be deep; but, if possible, should have a broad, flaring side toward the roadway. The outside bank should be flat enough to prevent slipping. When the road is in an excavation, ditches should be provided so as to prevent the water from running down the centre of the road; the steepest grades need the ditches most. Where grades exceed 4 per cent. and the soil is loose and sandy, the ditch should be paved with cobblestones or field stone in order to protect the shoulders from wash. These gutters can also be used to advantage at intersecting roads where there is not sufficient headroom for a culvert.

As a rule, the ditches, culverts and the roadside in particular, along our highways do not receive the attention they deserve. Often we find weeds and brush growing along our main roads, blocking the flow of water and preventing it from escaping quickly to the outlets, and besides, their existence is not pleasing to the eye. It is not a rare occurrence to see culverts almost wholly blocked with weeds and silt, thus causing unnecessary flooding and damage. It is admitted on all sides that drainage is of the utmost importance to all roads. Such being the case, it behoves us to see that everything be done to keep the highway in as perfect a condition as possible.

In providing for cross-drainage only permanent material should be used, for the failure of a cross-culvert will not only block the drainage, but will damage the road surface and may cause accidents. Cross-culverts are required to distribute the water to natural channels, so that the side ditches do not carry too much water. While the cost of carrying water away from the side ditches often seems prohibitive, the expense is always warranted by the better construction obtained. When impossible to provide complete drainage the elevation

Showing Effect of Poor Drainage on Concrete Road.

of the subgrade should be at least two feet above high water level.

The main object in underdrainage is to lower the water level in the soil; in other words, to intercept the ground water before it reaches and soften the subgrade.

In many cases a line of tile on one side of the road is usually sufficient. In these cases the tile should be placed on the high side of the road, preferably under the ditch where the greatest depth can be obtained with the least excavation and where the water is caught as it flows out of the hill. Sometimes a section of a road is wet because of a spring, or perhaps the road is muddy because of a stratum which brings the water to the road from higher ground; in either case, the source of supply

Tile Drains More Desirable than Blind Drains.

should be tapped with a line of tile instead of trying to improve the road by piling up earth.

All drains should be carried to a proper outlet, either to a culvert, to another drain, or through a bank. When the drain is carried through a bank the outlet end should be protected by a masonry or concrete wall which extends back along the pipe for a distance of three feet, thus preventing the water from undermining the pipe at this point.

There are places along a road where the water may be turned off at either side, such places, for instance, as a fill, with the ground sloping away from the road on both sides. If there is much water to be turned over the bank it will be necessary to protect the bank from washing out. A small amount of water running down high banks composed of sandy soil is liable to cause great damage, for the small gullies made by the water may rapidly extend back into the road surface. The bank should be protected by sod, or a paved channel should be constructed down the side of the bank to carry the water. In soils where there might be some question as to the advisability of using a gutter, a vitrified pipe or a wooden trough may be constructed down the side of the bank.

In planning the drainage for a road improvement it is well to make as few changes as possible from the existing scheme.

After drainage is secured, the important points in road foundations are the removal of all vegetable matter and to build up the foundation uniformly. Dragging and planing the subgrade as it is being built will prevent the waviness of surface which develops occasionally after the completion of a road.

The subject of foundations will be considered under two heads, viz., Natural Foundations and Artificial Foundations.

With the exception of earth roads, the construction of all of the more common types of roads might be described as three distinct steps, viz.: the construction of the subgrade or natural foundation, the construction of an artificial foundation, and the construction of the wearing surface. Therefore, the lower courses of either a macadam or a gravel road might be considered as types of artificial foundations.

Any subsoil will generally be improved by rolling, and such a process will show up weak spots that should be replaced with other material.

As a rule, the subgrade does not receive the attention it should in construction; it cannot be too carefully prepared. It should be thoroughly drained and compacted, soft material removed and fills allowed to settle before the foundation, which is to carry the wearing surface, is laid. It is the subgrade that carries the load and

resists the blows of heavy traffic. The real foundation of a road is the earth subgrade, and it develops its greatest bearing power when dry.

A Natural Foundation is one where the surfacing material is laid directly upon the subgrade. Gravel or a sandy loam, when properly prepared, makes a suitable foundation for macadam or concrete.

Before concrete is laid as a surfacing or a foundation on an earth surface, a layer of cinders, gravel or crushed stone as a cushion should be spread to keep the moisture away from the base of the surfacing. This construction would lessen the number of cracks in the concrete surface.

When gravel is used as a sub-base for concrete surfacing it should be absolutely free from clay or loam, and rather sandy.

Surfacing with gravel constitutes a large portion of rural road work, and a great deal of money is wasted in not properly preparing the foundation for this surfacing. Common practice is to place gravel to a depth of from 6 to 8 inches on clay soil, frequently on a newly-shaped roadbed. Until compacted the coat of gravel serves as a sponge, holding the water until the subgrade is softened, thereby allowing the material to be cut through and much gravel lost, with a consequent rutted and uneven condition of the surface.

Foundations for gravelling should be firm and hard, and on new work this may be accomplished by forming a crust with a mixture of 2 or 3 inches of sand and gravel with clay subsoil, rolled to a smooth surface. On a sand subsoil it is equally necessary to have a foundation to prevent loss of gravel, and in such cases clay mixture is required.

Most gravel contains a proportion of silt or loam sufficient to draw moisture, so that the frost will work into it, and, of course, when the frost thaws, it leaves the material porous, spongy and wet. This condition is made worse by the traffic, which tends to puddle the surface, drawing the moisture from below. Such a result may not be serious if the road is of gravel or waterbound macadam, for such can be easily and cheaply repaired, but if the surface is bituminous, it may be ruined. It should be borne in mind that a road may stand up two or three years over a poor sub-base with little apparent trouble, but go to pieces the third or fourth year. This fact has caused a great deal of trouble; for the inexperienced man, finding that a road stands all right the first year, assumes it will continue to do so, proceeds with the same type of construction under similar conditions until the first fails and the whole road is ruined.

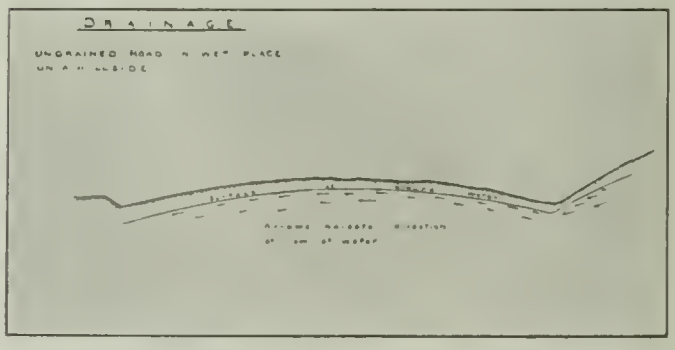
Artificial Foundations.—Among the artificial foundations suitable to lay a surfacing to meet the traffic requirements are concrete, rubble, telford, broken stone or gravel. The character of the foundation to use depends on the volume of traffic, the type of surfacing to be placed thereon and the natural soil conditions.

A gravel foundation should be thicker than a crushed stone foundation, as the fragments do not interlock as firmly as crushed stone. The choice between a gravel or a crushed stone foundation rests entirely on the relative cost.

When crushed stone is used as a foundation the size of stone should be $2\frac{3}{4}$ to $3\frac{3}{4}$ inches, but where local stone is used the size may be from 1 to $3\frac{3}{4}$ inches in order to take up the total output of the crusher. Crushed stone must never be laid on a soft subgrade. The distributing power of this course depends largely on the stone fragments being firmly interlocked. If the stone is placed on a soft subgrade and rolled, the earth will squeeze up between the fragments and separate them. The course should be rolled until no movement is under the roller.

One of McAdam's theories was that no stone larger than two inches should be used in a road. But experience has shown that this size of stone is unsatisfactory for foundations and is only suitable for surfacing. With crushed stone the units are so small they have little bearing, and, as they have no cohesion when wet, sink readily. It should also be borne in mind that the cost of crushed stone is greater than the larger size stone.

A type of foundation used to a great extent in the United States is the V-drain. A V-drain, so called because it is really the shape of a flattened "V," is constructed by excavating the roadway for its full width, from 4 to 8 inches deep at the sides and from 12 to 18



inches deep at the centre. This excavation is filled with stones not over 8 inches in size. The larger stones are placed at the bottom of the trench and the smaller stones at the top. This V-drain is a combination of foundation and drain. The water flows in a channel in the centre of the road, whence it is led off by bleeders to proper outlets. A V-drain should only be used where the road lays over a wet or heavy soil.

The objection to the V-drains is that, owing to the extra depth of stone in the centre of the road, the frost action is not as great at that point as at the edges, where

the stone is lighter, and a considerable distortion is occasioned in the road surface when frost sets in.

Field-stone or flat, rubble stone are sometimes substituted for the V-drain foundation. When flat stones are used, they are laid on the subgrade on their broadest face and small stones thrown on the surface to fill the crevices; the whole is then rolled until hard and firm. This type of foundation has given satisfactory results and is much cheaper than the Telford foundation. If a bituminous surface is to be placed on this foundation, a layer of clean sand should be spread over the surface of the foundation, so as to fill the voids. This is rolled without wetting and any surplus material swept off. The sand is only used to prevent loss of bituminous material, and is not an essential part of the foundation. Bleeders are used, where necessary, to drain the water from the foundation.

The Telford foundation as a base for macadam surfacing is well known. Properly laid, the supporting value and stability of such a foundation is high, and in many cases its use has been economical. On the other hand, the development of traffic conditions has resulted in such severe strains on these foundations that they have failed, probably most of the failures being due to unevenness of surface obtained, and a consequent lack of uniformity in the thickness of the surfacing. A Telford foundation which has been used as a base for a water-bound macadam surface, from which the macadam has been worn off, makes almost an ideal foundation, when brought to a true surface, upon which to lay a bituminous surface; provided that the stones have been originally set on a proper subgrade.

When roads are constructed with a view of utilizing in the future such construction as a foundation for some form of surfacing, the Telford method of construction is one that should be considered.

The quality of the material used as a foundation need not be as good as that on the surface, since it will not be subjected to the wear of the traffic.

Artificial foundations constructed with stone aid the drainage, besides directly improving the bearing power of the soil.

Concrete, apparently the highest type of artificial foundation, has become an approved foundation for any block or asphaltic concrete pavement, and is used chiefly on city streets. The necessity of using a cushion on the concrete foundation is one about which opinions differ.

The foundations for higher types of road surfacing, such as bituminous and concrete, require perhaps even more attention than for gravel or macadam roads. The material must not only be firm, with adequate provision for drainage, but the subgrade must be thoroughly drained out before the surfacing is placed. Most of the cracking and failure of concrete roads has been due to moisture in the subgrade at the time frost sets in.

Often we hear that a waterproof surface requires little or no foundation, because no water can get through it to the soil beneath, so the base is kept dry. This statement is entirely erroneous. A little consideration of the capillary action of the soil, which water from the sides of the road and underground sources, as well as the water that will seep through the soil from higher points, will show that a waterproof surface is not sufficient unto itself without a proper foundation. Each road is a problem in itself, and no standard treatment can be devised that will fit all conditions. There are many factors entering into the problem: soil, drainage, traffic, available material—all should be considered.

An economical design of foundation for macadam roads may be summarized as follows:—

For moderate traffic use pit-run gravel, local gravel if available, varying the depth to suit the soil. If gravel is not available, use crushed stone for ordinary soils and field-stone for bad foundations. The economy in the design of macadam roads is greatly increased by utilizing local material, preferably uncrushed, to its fullest extent. If the supply of local material is limited it should be used for as much of the road as possible, and advantage should be taken of the different local supplies by changing the design to allow their use with short hauls.

In planning the construction of a new road it is wise to go over the road in the spring when the frost is coming out and notice the bad spots, the spots that heave, and then when you build your road you can take these spots and provide some method for taking care of the ground water. If not, then in the summer the road is as hard as any other part.

The stability, permanence, and the maintenance of any road depends upon its foundation. If the foundation is weak, the surface will quickly settle unequally, forming depressions and ruts.

The essentials necessary to the forming of a good foundation are:—

(1) The drainage of the subsoil wherever necessary.

(2) The entire removal of all vegetable matter.

(3) The thorough compacting of the natural soil by rolling.

(4) The placing on the natural soil so compacted a sufficient thickness of an impervious material which will effectually cut off all communication between the soil and the bottom of the surfacing.

To ensure the stability of a road surfacing it is essential to have as firm and as good a foundation as for any other structure.

NEW PLANT FOR THE MARITIME PROVINCES.

What is said to be the largest concrete tile, pipe, brick and block factory east of Toronto has been fully equipped at Fredericton, N.B. A three-story brick and concrete factory 50 x 100 ft. has been equipped throughout by the Fredericton Concrete Co. with the most modern machinery for turning out the product entirely automatically and at high speed.

All products, as they come from the machines, are conveyed on cars to curing kilns and steam-cured for forty-eight hours. Sand and gravel are elevated from a storage pit in the basement by chain carriers to a large revolving screen at the top of the building. This screen separates the sand from the gravel, the sand going to a bin placed over the mixer. Over-size gravel and stones are carried to the crusher and then fed to crushing rolls, the pulverized product being carried back to the sand-pit. From this storage bin the material feeds to the power mixer from which the flow of concrete gravitates to different machines. As a result of this arrangement, the material is hardly touched from the time it is delivered at the factory until it comes out as a finished article.

The brick press puts a pressure of 200,000 lbs. on the material with a double repress. It has a large capacity and covers a wide range of work. The sewer pipe machine makes pipe from 5" to 48" in diameter, and from 24" to 30" long with either square or socket joint ends. The tampers on this machine work between the revolving core and casing, striking 450 blows per minute with a 400-lb. force on each blow, compressing the concrete thoroughly.

The drain-tile machine makes 3", 4", 6" and 8" tile 12" long, and 12", 14" and 16" tile 18" long with square joint ends. This machine has a capacity of several thousand tile per day. The block press develops a pressure of forty tons, making a very strong building block of excellent fireproofing, moisture-proofing and frost-proofing qualities.

EARTH PRESSURES: A PRACTICAL COMPARISON OF THEORIES AND EXPERIMENTS.*

By L. D. Cornish, M.Am.Soc.C.E.

OF all structures which the engineer of to-day is required to design for conditions of static loading, there is probably none which is so irritating as the ordinary retaining wall. This, of course, is due to the lack of definite and correct data relative to the pressures exerted by the various kinds of earthy materials and to the variety of formulas which have been proposed for determining the amount and direction of the resultant earth pressure which acts on a retaining wall.

The writer has studied with a great deal of interest all the books and papers he could obtain concerning earth pressure theories, and the formulas or graphical analyses derived therefrom. Such study has been confined principally to a comparison of solutions based on the Rankine theory with those based on the sliding-wedge theory, and certain facts were developed which appear to discredit, in certain particulars, these commonly accepted theories. It is quite probable that other investigators have observed at least some of the same results, but, as the writer had never seen them discussed, he thought the matter of sufficient importance to assemble the results of his studies in this brief paper.

The nomenclature used in Figs. 1 to 15, and discussion thereof is that used by Cain in his paper discussing Leygue's experiments, and, for the remainder of this paper, is the same as that used by Ketchum in his "Walls, Bins, and Grain Elevators." The differences are few and should cause no confusion, and the use of both will facilitate quick comparison with the works of the authors mentioned.

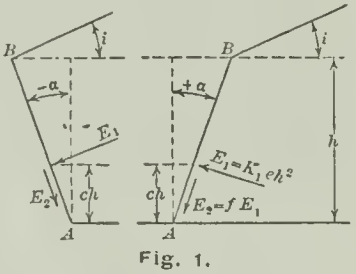


Fig. 1.

h = vertical height of wall;

ch = vertical height to centre of pressure on AB, Fig. 1,

$$c = \frac{1}{3};$$

ph = width of base of wall;

p = ratio of base to height;

e = weight of earth per cu. ft. (Cain-Leygue);

w = weight of earth per cubic foot (Ketchum);

W = total weight of earth per linear foot;

w_1 = weight of wall per cubic foot;

W_1 = total weight of wall per linear foot;

P = resultant earth pressure per lin. ft. of wall;

P_H and P_V = the horizontal and vertical components, respectively, of P;

$E_1 = K_1\ eh^2$ = normal component of P (Cain-Leygue);

$E_2 = E_1 \tan. \phi^1$ = component of P parallel to back of wall (Cain-Leygue);

k = cohesion, in pounds per square foot (Cain-Leygue);

K_1 = coefficient of E_1 (Cain-Leygue);

i = inclination of surface of earth to horizontal (Cain-Leygue)

δ = inclination of surface of earth to horizontal (Ketchum);

α = angle between back of wall and the vertical, counted as positive or negative, as in Fig. 12 (reproduced herein as Fig. 1) (Cain-Leygue);

ϕ = angle of repose (internal friction) of the earth fill;

ϕ^1 = angle of friction of the earth filling on the back of the wall;

θ = angle between the back of the wall and a horizontal line extending into the fill = $90 + \alpha$;

$r = \frac{1 - \sin. \phi}{1 + \sin. \phi}$ = the Rankine ratio of horizontal to vertical earth pressures = k, as used by Ketchum.

In discussing his solution of the sliding-wedge theory, Cain refers to various experiments, among which are those made by Leygue and in Table 3 of his paper before this Society. Cain gives certain results of Leygue's experiments. Leygue's experiments were made with dry sand and retaining boards, AB, which could be rotated about the bottom, A, in order to produce any desired inclination to the vertical, as shown by Fig. 1. Suitable observations were taken and results obtained, from which the values of K_1, as given in the last column of Cain's Table 3, could be computed. The reader is referred to Cain's paper "Experiments on Retaining Walls and Pressures on Tunnels," for additional details.

The values of K_1 show the relative variation in the total normal thrust against walls under different conditions of loading and inclination of the back of the walls, but convey no immediate idea of the dimensions of the walls necessary to withstand such thrusts, and, after all, the dimensions are of most interest to the practical engineer or designer.

As a preliminary to the discussion of the formulas in common use, and to provide for subsequent comparison of designs based on theory with those based on experiments, retaining walls were designed to satisfy the experimental values of K_1, as given in the last column of Cain's Table 3. In designing the walls, the unit weight of earth, e, was assumed at 100 lbs. per cu. ft., and the weight of wall, w, at 140 lbs. per cu. ft. The resulting designs are shown by Figs. 2 to 8, and it may be noted that the values of e and h selected are such that $eh^2 = 10{,}000$, and, consequently, the normal thrust, E_1, is 10,000 times K_1, or the significant figures of E_1 of the designs and of K_1 of Cain's Table 3 are the same.

The width of the base of the walls, ph, was computed from the equations for p shown for Figs. 2 to 15, which equations are conditional on the resultant of all forces piercing the outer-third point, and the design was checked graphically as shown in the figures.

It may be noted that the required width of base steadily increases from Fig. 2 to Fig. 8. It is believed that any engineer, given these seven different cases at the same time and in a graphical form, would expect such a progressive increase, and that, in all cases, he would assert that an increase in the angle of surcharge, i, would require an increase in the width of the base. It is this point only which the foregoing discussion of Leygue's experiments is intended to emphasize for subsequent reference thereto.

In his paper, Cain showed that, in considering Leygue's experiments, the effect of cohesion should not be neglected, and, by graphical constructions and computations, he derives theoretical values of K_1, as given in

*Proceedings of the American Society of Civil Engineers.

the next to the last column of his Table 3 for assumed values of cohesion, k, as given in the third column of that table. It may be noted that the experimental values of K_1, as used in preparing Figs. 2 to 8, agree closely with the theoretical values, for k is equal to 1 lb. per sq. ft. Cohesion is usually neglected in practical designing, and, to show the effect of such neglect, walls, as shown by the smaller sections of Figs. 9 to 15, were designed for the theoretical values of K_1 corresponding to $k = 0$. All other assumptions were the same as those used for Figs. 2 to 8 and, therefore, the increase in section or base width is due entirely to the neglect of cohesion. The theoretical values of K_1 were derived by Cain from his theory; hence these are also the sections which result from the use of his formulas, and are marked for identification with his name.

reason and experiment on the other will doubtless be as surprising to many engineers as it was to the writer, and it will be discussed hereinafter in greater detail and for various conditions.

The second point of special interest is that, whereas the base of the experimental section, Fig. 4, is 30% wider than that of Fig. 3, yet the corresponding theoretical section, Fig. 11 (Cain), is 9% narrower than that of Fig. 10 (Cain). This indicates that, for walls with backs sloping toward the back-fill, the Cain and modified Rankine formulas give sections unnecessarily large. Walls of this kind are so unusual in practice that the writer, as yet, has made no further investigation of this case.

The third point is that the increase in base width of Figs. 14 and 15 (Cain) over that of Figs. 7 and 8 (Leygue),

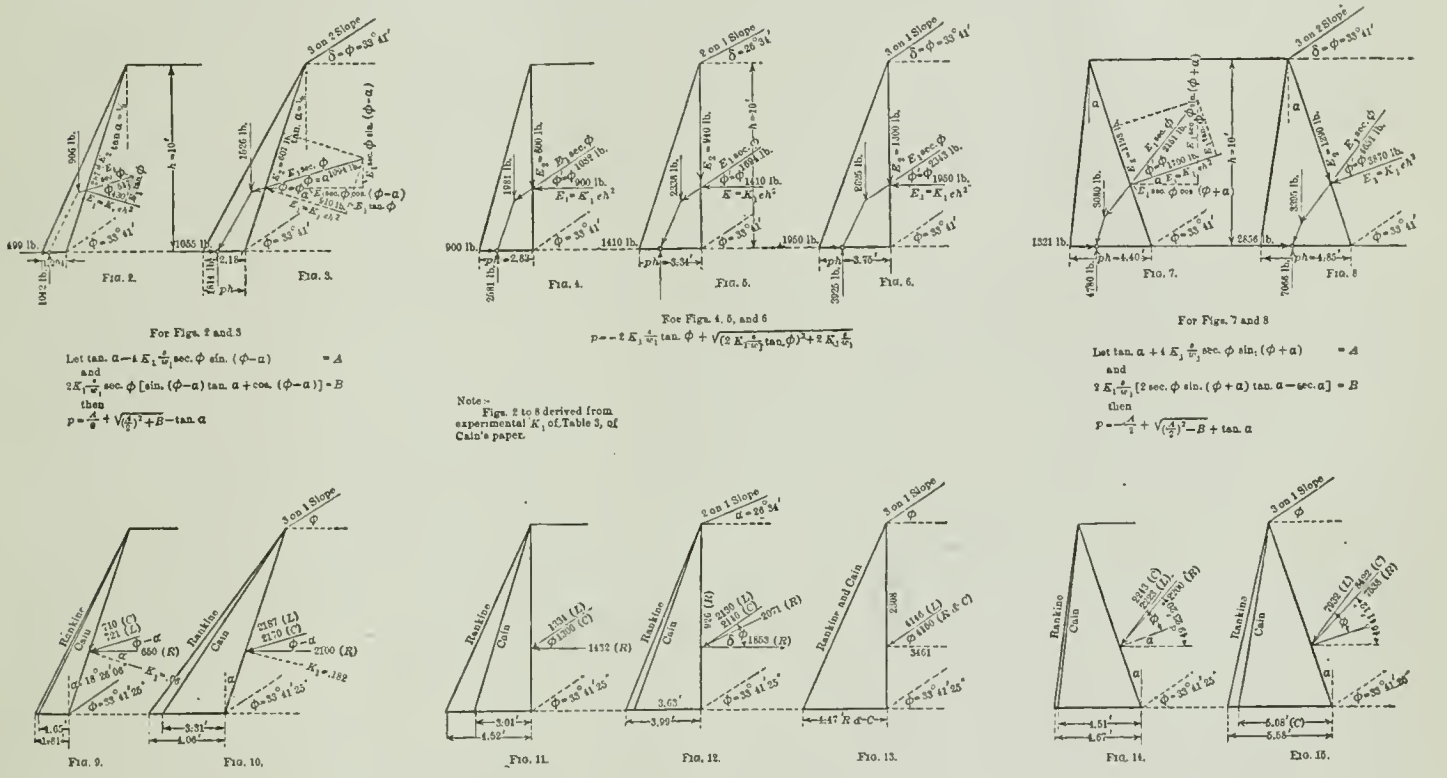


Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
For Figs. 2 and 3
For Figs. 4, 5, and 6
For Figs. 7 and 8
Note:- Figs. 2 to 8 derived from experimental K_1 of Table 3, of Cain's paper.

Note. The letters C, R and L in parentheses indicate that the figures accompanying them were derived, respectively, from formulas of Cain Rankine (modified), and theoretical values of K_1 for $k = 0$, as given in Table 3, of Cain's paper. The figures are shown for checking and comparison.

Figs. 9 and 10 Rankine, from data 17); Ketchum, page 35.
Figs. 11 to 15 " " Equations 6, 8 and 8a, Ketchum.

Figs. 2 to 15.

The base widths required for the same conditions were computed from the Rankine formulas, as modified by Ketchum or Howe, and the resulting sections are the larger ones marked Rankine in Figs. 9 to 15.

A study of these fourteen sections discloses three points of interest which warrant further investigation.

The first and most apparent point is the Rankine section of Fig. 12, which is smaller than the Rankine section of Fig. 11, although it is apparent by inspection that it should be larger on account of the 2:1 surcharge slope of the earth behind the wall. That it should be larger is proved by Leygue's experiments, as Fig. 5, with 2:1 surcharge, has a base 18% wider than Fig. 4, which has no surcharge. It is also noted that the Rankine section, Fig. 13, for a 3:1 slope has a base about 1% less in width than the Rankine section of Fig. 11, which has no surcharge. These discrepancies between theory and experiment indicate that the formulas derived from the Rankine theory are erroneous, at least for certain conditions. This particular disagreement between theory on one side and is much less than the corresponding increase for other comparable sections. This indicates that possibly the use of Cain's formulas for surcharged walls with a battered back results in sections only a little larger than for a case of no surcharge. Such is the case for walls with a vertical face and battered back, as will be shown hereinafter.

In order to put the formulas of Rankine and Cain in a comparable form, equations were deduced for p, the base width of triangular walls expressed as a percentage of the height. All the formulas for earth pressures as used are given by Ketchum ("The Design of Walls, Bins, and Grain Elevators"), and his nomenclature has been adopted for the following discussion in order to facilitate references.

The wall sections and equations are shown by Figs. 16 to 19 for the Rankine formulas, and by Figs. 20 to 23 for the Cain formulas. For the derivation of p, as shown, it is required that the resultant of all forces shall cut, and that the moments shall be taken about, the outer-third point of the base. The derivation of p for Figs. 16, 17,

18 and 20 is evident by inspection, as Figs. 17 and 20 require only the solving of the quadratic equation of moments.

For Fig. 19, the earth thrust, P, against the wall is the same as the thrust against the vertical plane, bc, of height, h_1. The height, $h_1 = h + h \tan. \alpha \tan. \phi$

$$= h \frac{(\cos. \phi \cos. \alpha + \sin. \phi \sin. \alpha)}{\cos. \phi \cos. \alpha} = \frac{h \cos. (\phi - \alpha)}{\cos. \phi \cos. \alpha}$$

By substituting this value of h_1, the equations shown on Fig. 19 are obtained, which equations are in a convenient form for practical problems.

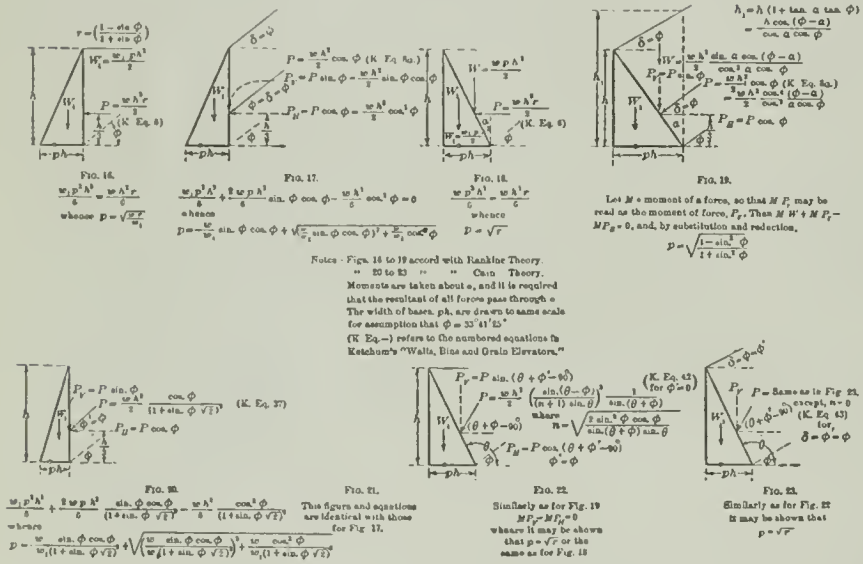
It is somewhat easier to derive p by substituting for h_1 its value, $h (1 + \tan. \alpha \tan. \phi)$.

The equation of moments now becomes,

$$\frac{wh^3}{6}\Big[\sin. \phi \cos. \phi (1 + \tan. \alpha \tan. \phi)^2 \tan. \alpha + (1 + \tan. \alpha \tan. \phi) \tan.^2 \alpha - \cos.^2 \phi (1 + \tan. \alpha \tan. \phi)^2\Big] = 0;$$

whence $\tan.^2 \alpha (1 + \sin.^2 \phi) - \cos.^2 \phi = 0;$

and $$\tan. \alpha = \sqrt{\frac{1 - \sin.^2 \phi}{1 + \sin.^2 \phi}} = p$$



Figs. 16 to 23.

For Fig. 22, the equation of moments is,

$$P \sin. (\theta + \phi - 90) \frac{h \tan. (\theta - 90)}{3} = P \cos. (\theta + \phi - 90) \frac{h}{3};$$

whence $\tan. (\theta - 90) = \cos. (\theta + \phi - 90) = p;$

or $\cos. \theta = \tan. (\theta + \phi);$

and $\cos. \theta - \tan. \theta - 2 \tan. \phi = 0;$

but, $\cos. \theta = -p;$

therefore, $p^2 + 2p \tan. \phi - 1 = 0;$

whence, $p = -\tan. \phi + \sqrt{\tan.^2 \phi + 1}$

$$= \sqrt{\frac{1 - \sin. \phi}{1 + \sin. \phi}} = \sqrt{r},$$

which is the same as for Rankine Fig. 18. It also may be shown that Pii and Pv (Cain) are equal in amount to P and W, as shown in Fig. 18.

For Fig. 23 it may be shown in a similar way that $p = \sqrt{r}$, but, in this case, Pii and Pv are greater in amount than for the similar forces of Fig. 22. (They are four times as great when $\phi = 30°$.) Therefore, an analysis of Fig. 23 shows that the surcharge merely produces greater compressive stresses in the wall, and the equations for p indicate that surcharging a wall does not increase its tendency to overturn so long as the unit compression stress remains within safe limits. Such an indication is so contrary to one's preconceived ideas of the effect of surcharge that the theory from which it results can scarcely be accepted until it is substantiated by experimental proof.

It may be noted that for Figs. 18, 19, 22 and 23, the equations for p show that the width of the base is independent of the weight of either the wall or the back-fill.

The equations for Figs. 16 and 17 give identical values of p for $\frac{w}{w_1} = \frac{100}{140}$ and $\phi = 0°$, 30°, or 90°; but p for Fig. 17 is the lesser for values of ϕ between 30° and 90° and greater for values less than 30°, although the difference is not marked, as will be shown hereinafter. The narrow base resulting from the Rankine surcharge formula is due to the assumption that the resultant earth thrust is parallel to the inclined surface, as this assumption introduces a vertical component which produces a resisting moment sufficient to balance the excess overturning moment due to the surcharge. This virtually means the assumption of frictional resistance on the back of the wall, an assumption which Cain makes for all cases in his solution of the sliding-wedge theory.

The figures and equations for p on Figs. 16 to 23 show inadequately the inconsistencies of both theories when applied to various cases, but they show that neither theory gives results for surcharged walls which accord with the inference drawn from wall failures or from the experiments of Leygue, namely, that for any type of wall, if the surcharge is increased, the section must also be increased, provided the walls must satisfy the requirement that the resultant shall cut the outer-third point, or any other common point within the base.

The difference between the cases shown by Figs. 16 to 23 is shown more clearly by Fig. 24, on which the p curves are plotted with reference to the rectangular co-ordinates, ϕ and p. The reference numbers on the curves refer to Figs. 16 to 23. The equations of the curves are either shown or reference is made to Figs. 16 to 23 on which they may be found, and for all equations including the weight of the wall and the earth, it was assumed that $\frac{w}{w_1} = \frac{100}{140}$.

Curves 1 to 8 of Fig. 24 show the difference between the Rankine and Cain formulas and also the formulas for the extreme conditions of no surcharge and maximum surcharge, but give no indication of the peculiar results obtained by the Rankine formula for Fig. 12, which is so much smaller than the corresponding wall, Fig. 11, which is not surcharged. This, however, is shown by the curves, 2a and 2b, in the equations for which ϕ is a constant and δ a variable between the limits, zero and ϕ. These curves indicate that surcharging a wall increases its stability against overturning, and that a minimum base width is required when the angle of surcharge is only a few degrees less than that of repose or of maximum surcharge. Curve 4a has no minimum for finite values of δ, but is similar to the others in indicating a rapid decrease in p for small decreases in δ from its maximum value of ϕ.

The equations of Curves 2*a*, 2*b* and 4*a* are as follows:

Let $A = \cos.\ \delta \dfrac{\cos.\ \delta - \sqrt{\cos.^2\delta - \cos.^2\phi}}{\cos.\ \delta + \sqrt{\cos.^2\delta - \cos.^2\phi}}$, (*K.* Equation 8), in which ϕ is a constant; then for 2*a* and 2*b*,

$$p = -\frac{w}{w_1} A \sin.\ \delta + \sqrt{\left(\frac{w}{w_1} A \sin.\ \delta\right)^2 + \frac{w}{w_1} A \cos.\ \delta};$$

and for Curve 4*a*,

$$p = \sqrt{\frac{A \cos.\ \delta}{1 + A \tan.\ \delta \sin.\ \delta}}.$$

It is obvious that inferences, relative to surcharged earth pressure, to be drawn from Curves 2*a*, 2*b* and 4*a*, and from the similarity of Curves 1 and 2-6, are fallacious, and that, consequently, the Rankine theory—that the resultant earth thrust is parallel to the inclined surface of surcharge—is erroneous.

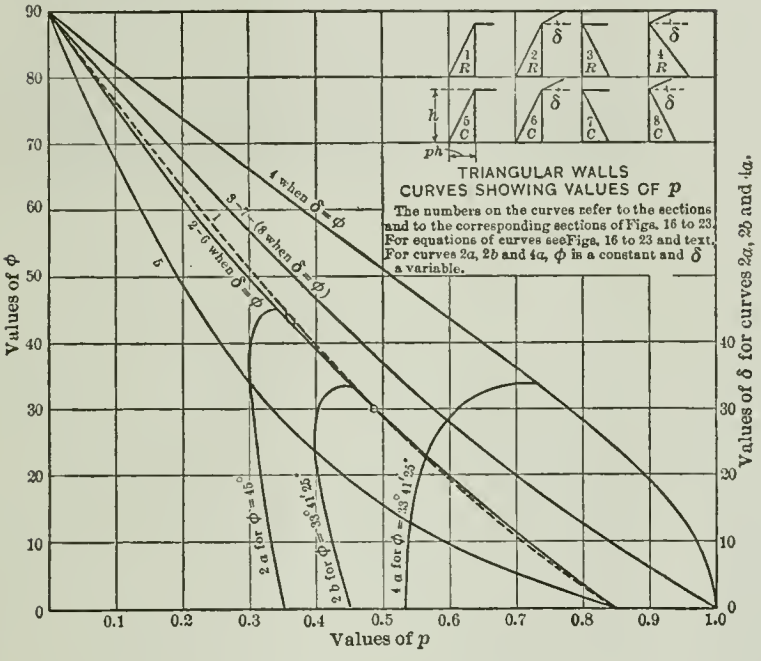

TRIANGULAR WALLS
CURVES SHOWING VALUES OF p
The numbers on the curves refer to the sections and to the corresponding sections of Figs. 16 to 23. For equations of curves see Figs. 16 to 23 and text. For curves 2a, 2b and 4a, φ is a constant and δ a variable.
Values of φ
Values of δ for curves 2a, 2b and 4a.
Values of p
4 when δ = φ
3-6 when δ = φ
2-6 when δ = φ
5 when δ = φ
2 a for φ = 15°
2 b for φ = 15°
4 a for φ = 33° 41' 53"
5 when δ = φ = 33° 41' 53"

Fig. 24.

The writer has never been able to find or think of any good reason for assuming that the slope of surcharge should govern the slope of the resultant earth thrust for great depths, but will refrain from discussing it, as it is not the object of this paper to present a theoretical discussion, but to show, in as practical a way as the writer could devise, the results obtained from the application of the two principal existing theories.

By the end of 1916 the electric railways and tramways of Switzerland numbered 104, and their lengths aggregated 1,678 km. According to the tabulation given in the "Schweizerische Bauzeitung, of February 3, 1917, the length of the ten standard gauge railways is 172 km.; of these, 20 per cent. are on the continuous-current system, 22 per cent. on the three-phase and 58 per cent. on the monophase system. On the 63 narrow-gauge and rack railways (one of which, 8.6 km., is standard gauge), of 1,020 km. length, continuous current predominates strongly, 87 per cent. of the lines being on this system, and only 4 and 9 per cent. on the three-phase and monophase systems. The 31 tramway lines, 1,486 km. in length, are with one exception (monophase system) equipped for continuous current. On standard-gauge railways the preference for monophase service has long been pronounced.

INCREASING THE SAFETY OF OUR HIGHWAYS.*

By W. H. Losee, B.Sc.,
Assistant Engineer, Department of Public Highways, Ontario.

OWING to the growing volume of traffic on our highways and the increasing speed of vehicles the type of roads that were once built for the slow-moving horse traffic are not now adequate for the fast-moving motor traffic. Not only is the character of the road surface itself not adequate but the alignment and grades are receiving more attention now than they did twenty years ago.

Because we are still using the roads with steep grades, crooked alignment, and in some places narrow roadbed, many accidents occur where a few years ago an accident of the same nature was unheard of and we must begin to correct these defects or accidents will increase as steadily as the use of the motor vehicle is increasing.

Besides the accidents that occur from the above causes, the most serious and common kind are those which happen at level railway crossings, and their prevention is becoming a very important matter.

Since the motor vehicle has become so universally used the tendency has been for the city dweller to live somewhere in the suburbs and go back and forth to his office in his car. This has increased the traffic on streets that the railways are bound to cross and automatically increases the dangers of level crossings. Motor traffic in the suburban areas is very heavy between the hours of 7.30 and 9 a.m., and 5 and 6.30 p.m.

On the other hand, the man who lived in the country a few years ago, used only the roads that took him to his post office, to church, and to his market place and shipping point. Ten miles was an average radius for any farmer and he generally knew the dangerous crossings, and about the time any fast train would be crossing them; the result being that there were very few accidents.

But the motor vehicle has changed these conditions entirely. Motorists are continually going into new country, railway crossings are encountered everywhere, and sometimes when they are least expected. Generally a car carries from four to five people who must depend upon the judgment of the man at the wheel. He cannot, therefore, afford to be careless because any accident is bound to injure more people than the driver, and it does not seem fair that people should be exposed to danger by a man who tries to be too "smart" or careless. Crossings should therefore be made as nearly as possible "fool proof."

There are many different methods of protecting a railway crossing. There is the overhead crossing, the subway, the gates, the watchman, the electric bell, and the "danger" sign post.

Let us first consider the subway. This measure of protection is undoubtedly the best one of all, but the cost of its construction, except in thickly settled districts, almost makes it prohibitive. It may cost anywhere from $30,000 to $150,000 to construct one subway, and as the crossings in Ontario are many, any undertaking to separate all crossings would bankrupt the province.

There are subways already built in Ontario that are so constructed that they are now a menace to the travel-

*Read before the 3rd Annual Conference on Road Construction, March 27-30, 1917.

ling public. The centre line of the subway was generally built at right angles to the line of the railway instead of being parallel with the centre line of the highway. The result is a bad turn at the entrance and exit of the subway and the view along the highway is so obstructed as to make a serious accident possible.

This trouble can now be largely done away with as the plan for each proposed subway must be submitted to the Dominion Railway Board or the Ontario Railway and Municipal Board by whom local conditions are thoroughly investigated.

The next best way of protecting a crossing is by means of gates. These can be operated at about $800 per year, and have been in use for many years, but they are defective because people often run under them and the bars have been broken many times by vehicles running into them.

Watchmen have also been used for a long time as a means of protection to the public at crossings, but should a crowd or a reckless motor driver or an unruly horse wish to cross the tracks, he is powerless to prevent them. The watchman is, as a rule, never dressed any differently from the ordinary person and there are times when it is difficult to distinguish him. A great help in this regard would be to dress him in some kind of distinctive clothes and have a uniform standard of signals that everyone would understand and, if it be found possible, give him the power of a constable so that he could arrest anyone who disobeyed him or the law.

The electric bell is used to a great extent on country railway crossings and it has proven to be a very good warning signal. They, however, have been known to get out of order and ring for days before they are repaired, the result being that travellers would come up to the crossing, wait for a while and then when no train would come, cross over. Anyone fooled that way is naturally apt to disregard them entirely.

Lastly we have the sign of "danger." These are placed by all railways on the right-of-way at the crossing.

A Dangerous Bend.

If a driver should come around a corner or any obstruction that would be near the crossing, suddenly upon the crossing he may be too close to stop and the sign at the crossing is naturally of little use. It would be much better if all danger signs were placed about 400 feet from the crossing and were so placed that they would be readily seen. They should be painted white so that they have the best chance of being seen at night.

The manner in which subdivisions have been laid out in parcels of land that are cut by a railroad have been the cause of much expense to railways and municipalities when these lands are built upon. Surveyors paid little attention to the number of crossings that would be necessary in the event of the growth of the town. According to their surveys a crossing is necessary where each street on the plan crosses the tracks, but had they allowed for a narrow street paralleling the railway on each side of the track, subways could be built or gates put up at proper

Ditches Such as This are a Menace.

intervals so that there would be the minimum number of crossings to serve the maximum number of people. This gives the driver of the engine a chance, he can be more careful at the crossings and still make better time, the number of subways, gates or watchmen would be reduced and likewise the cost of maintaining them would be lowered. The Dominion Railway Act requires that all approaches to railway crossings should not have a greater grade than 5 per cent. It is because of these steep approaches that a car sometimes stalls on the crossings and makes an accident possible.

There is little doubt that carelessness on the part of pedestrians and drivers of vehicles is the great cause for many accidents and if people can be taught to be careful, the number of accidents will be considerably reduced.

The Ontario Safety League and the Ontario Motor League, with the aid of the government and the railways, are doing a grand work along the line of educating people to be careful, and we can all do missionary work along these lines. The phrases "Safety First," and "Stop, Look and Listen," are commonly used now. But how many people heed the latter phrase at a railway crossing? Very few people stop and look, some slow up and look, some just look one way and others never slow up or look at all; they simply take a chance.

In an article entitled, "Accidents at Grade Crossings," written by Mr. Alex. Gordon, a commissioner of the State Railroad Commission of California, there are some very interesting facts with regard to the carelessness of the travelling public.

He says: "The Southern Pacific Railway Company recently made test observations at thirty-four crossings. They observed over 17,000 motor vehicle drivers and found that 69.5 per cent. looked neither way before crossing the tracks, 2.7 per cent. looked in one direction only and but 27.8 per cent. looked both ways. 19.3 per cent., or the incredible number of 3,300 drivers ran over crossings at a reckless rate of speed. Only 35 drivers or two-tenths of one per cent. stopped their machines before crossing the tracks.

"Four thousand nine hundred drivers of teams were observed, 39.4 per cent. of whom looked in neither direc-

tion, 8.6 per cent. looked one way only and 52 per cent. looked in both directions. Of 6,300 pedestrians observed, 49.1 per cent., or practically one-half of the total, looked neither way; 15 per cent. looked in one direction only, and 35.9 per cent. looked both up and down the track." The same company has tabulated the accidents on grade crossings which have happened during the last five and one-half years in an attempt to secure the reasons for these accidents with the following results:—

	Killed.	Injured.
Ignored train and its warning	35.0%	37.1%
Ignored train and its warning and warning of crossing bell, automatic and human flagman, and warnings of other persons	13.8%	12.6%
Ran into side of train	10.1%	15.3%
Stalled on track	7.8%	4.2%
Tried to beat train to crossing	16.0%	9.3%
Other causes	17.3%	21.5%
	100.00%	100.00%

This company during two years had 525 crossing gates broken by vehicles which drove into them when they were down.

In the United States during the year ending June 30th, 1916, there were 1,310 people killed and 3,184 injured on highway grade crossings of railways.

On the Central Railway of Georgia, 78,275 drivers of motor cars, motorcycles and horse-drawn vehicles were observed at railway crossings and of these 59,700 did not look in either way before starting across the railway, or in other words, about 75 per cent. took no precautions whatever, even though they were approaching the danger zone of the railway.

Nor do accidents always occur at dangerous crossings. At Thamesville, Ont., last year at the Grand Trunk Railway crossing, three people who were driving in an automobile were killed. The crossing was equipped with an electric bell, there was a red warning light designed to show the approach of a train, and 50 feet from the crossing there was a clear view of the track for two miles.

In order to make people be more careful, a law in Paris, France, was enacted which made it possible to arrest any pedestrian who was hit by a moving vehicle between street intersections. This resulted in the reduction of accidents by 50 per cent. On the other hand, any driver who was found guilty of breaking the traffic regulations had his license cancelled. The people soon learned that the proper place to cross a street was at an intersection where the vehicular and foot traffic was regulated by a police officer.

As was mentioned at the beginning of this paper, there are many other features of our highways that take their toll in accidents.

The narrow road with the high crown that compels motorists to stick right on the top and make the man with the horse move well off or lose control of him has caused more than one casualty. Besides the harm done to the road by continuous travelling in the same rut, the road with too steep a crown is dangerous. If it happens to be wet and slippery motorists, believing that it might be difficult to get back on the road, or fearing they would slide into the ditch, do not care to turn out.

If it is a man with a load of hay, there is a possibility of it overturning when he pulls out on the steep side.

The width of road is pretty well governed by the traffic it has to withstand. It should have a crown that would shed the water, and yet be wide enough so that traffic would be diffused over the whole surface. It should always be borne in mind when contemplating construction that immediately a road is built traffic will increase and the type of road should be designed with this increase of traffic in view.

The steep, narrow road on a hill with a sharp turn at the bottom is another source of danger and makes many anxious moments for the driver of a heavy load or a motor vehicle. Sometimes the brake refuses to act and he is going so fast that he cannot make the turn at the bottom and plunges headlong through the flimsy railing, causing destruction to the car and certainly injury to its occupants.

A dangerous condition like this can generally be averted by a change in the location of the approach to the bridge or of the bridge site itself; perhaps a longer, easier grade could be found or by raising the bridge the approach to it could be rendered less liable to cause a serious accident.

Owing to the nature of our early surveys there are many jogs and sharp turns on our roads. In one county

A Dangerous Turn in Road.

there are turns greater than 90°. It has caused this county no small amount to make these turns safe and still keep within the road allowance. This was done by raising the outside of the road by the addition of more stone, which enables the driver of a car to make the turn without a chance of an accident. An improvement on this is to lengthen the curve by using a piece of the land adjoining.

The grade of the steep hills could be reduced and the sharp turns eased, if the owner of the adjoining land could be brought to see the great benefit he would confer on the travelling public, and the words of commendation he would bring from everyone, if he would consent to sell it at a reasonable figure.

All narrow fills, approaches to bridges, and deep ditches, should be protected by a good strong guard rail. The deep ditches in the clay sections of Essex and Kent counties are very dangerous. When the clay road surface is wet it becomes so slippery that to turn out in some of the narrow places is a very hazardous undertaking.

These roads should be surfaced with any material that would reduce the slipperiness and a guard rail should be built at the edge of the ditch. Many of the ditches were dug years ago when the traffic was not as it is at present.

They were put within the road allowance when they should have been dug in the adjoining field. From now on it is going to cost something to render them safe.

Warning notices of steep hills, sharp turns, and railway crossings should be erected at proper distances from them. It would be advisable to have these signs standard in form and placed in the most conspicuous position.

The Ontario Motor League have done something in this regard, but their signs are often stuck up on telegraph posts, and in places where they are not always readily seen. These signs are a great help on the main travelled roads but the motor car is now found in the most remote districts and it is there where the dangerous roads are, and where signs denoting danger are badly needed.

Another matter that is giving some concern to the county road superintendents and motorists is the erection of rural mail-box posts too near to the travelled road. It makes it difficult to grade properly and they are sometimes so close to the road as to be a menace to the safety of the travelling public. This has been inquired into and the following are the rulings of the law clerk of the Post Office Department:—

Circular No. 86.

CIRCULAR TO POST OFFICE INSPECTORS.

The inspector will find, in the law clerk's opinion quoted herein, a ruling governing several questions which have been raised, affecting rural mail delivery service:—

1. Responsibility for accidents resulting from collision with rural mail box posts.

2. Right of township or county authorities to compel the removal or displacement of rural mail box posts.

3. Action to be taken by municipal authorities where it is considered that the box posts are in a dangerous position.

4. Right-of-way to be exercised by courier in performance of service.

"The authority under which the Post Office Department is acting is paragraph (n) sub-section I. of section 9 of Post Office Act, as amended by 3-4 George V., chap. 38, section 2:—

"This Act is public Act.

"1. The amendment referred to authorizes the postmaster-general to cause the erection, on rural mail routes, of posts for rural mail boxes at such places as to him appear convenient.

"In my opinion such posts can, in no circumstances, be considered as an obstruction, but as public works for public utility.

"In these circumstances, no responsibility lies with the Department (or with the owner of mail box) for accidents which might happen through collision with said posts or otherwise.

"2. The township authorities have no power whatever to compel the removal or displacement of rural mail posts.

"3. Should, however, any rural mail box posts be inconveniently erected, the proper course for the township authorities to follow, is to petition the superintendent of rural mail delivery, Ottawa, who will have the matter investigated.

"4. The Act also authorizes the postmaster-general to make regulations to render the said Act effective.

"The rural mail regulations so made, provide that the courier shall collect and deposit mail matter from and in mail boxes without being obliged to leave his rig.

"This, therefore, authorizes the courier to cross the road from right to left when necessary to serve a box, and, naturally to stop on the left side of the road the required time to diligently serve said box.

"He is consequently given such privileges and rights of way as are required and necessary to perform his duty as courier.

"But outside of the above, the Act or Regulations confer upon him no special right-of-way on public roads.

"In such rights as are conferred upon the courier are protected by Section 125 of the Post Office Act, which makes it an indictable offence to obstruct wilfully the progress of the mails.

"(Signed) A. Bolduc,
"Superintendent."

Post Office Inspector, Kingston, Ont.

In conclusion, we should all remember that carelessness is the cause of a great percentage of accidents. Education along these lines, although seemingly slow, is achieving results; and everyone should bear in mind that "an ounce of prevention is worth a pound of cure," and we should do all in our power to reduce the number of accidents that are taking the lives of our citizens, when human lives have more value to the country than they ever had before.

BRITISH COLUMBIA ENGINEERS VISIT PREMIER

Requesting that the British Columbia government use engineers at present in the province, or at least in the Dominion, before going elsewhere for engineering services, a deputation from the British Columbia Society of Civil Engineers interviewed the provincial premier last week.

The question of a charter for the new society was touched upon and the premier expressed his pleasure that it was not the intention of the society to ask for a closed corporation, but that their object was "to unite the engineers of the province so that the status of the profession might be kept at a high state and that the members might benefit by exchanging their individual knowledge on the different specialized branches of their calling."

The deputation consisted of E. N. Horsey, resident engineer of the B.C. Electric Railway Co.; Mr. Seaton, engineer of the Public Works Department of the Dominion Government at Vancouver; Mr. Robertson, resident engineer at James Island for the Canadian Explosives Co.; Frank M. Preston, assistant engineer of the Sewer Department of Victoria; Bateman Hutchinson, civil engineer and land surveyor of Victoria; Mr. Macrae, assistant Dominion Government engineer on the breakwater work and honorable secretary of the society.

The Dominion Steel Foundry Co., Ltd., and the Hamilton Steel Wheel Co., Ltd., are to be amalgamated through an exchange of shares of the two companies for shares of a company to be incorporated under the name of the Dominion Foundries and Steel, Limited.

What is believed to be the longest concrete trestle in the world was completed by the California State Highway Commission and formally opened last year. The trestle is nearly three miles long, and traverses the Yolo basin, a marshy tract more than 120 miles long, which is flooded for six or eight months annually. There is a clear width of driveway of 21 feet. The average height of the trestle is 20 feet. It consists of reinforced beam and slab construction in 20-foot spans resting on reinforced concrete piles 32 to 50 feet long. The material cost $148,000 and the construction $246,000. The work was done by contract, the material being furnished by the commission.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

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BOOK REVIEWS.

Manufacturing Costs and Accounts. By Hamilton Church. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1917. 452 pages, 139 figures, 6 x 9¼ ins., cloth. Price, $5. (Reviewed by H. W. Cowan, consulting engineer, Toronto.)

This work is divided into three parts, giving outline of manufacturing accounts, of cost accounting, of factory reports, respectively; copiously illustrated with forms and diagrams, and well indexed.

It is a valuable addition to the multitudinous works on cost accounting, so many of which are but explanations of systems in use in present plants, having comparatively small educative value.

Here the author rather deals with the practical application of fundamental principles, throughout keeping before his readers the necessity of paralleling the commercial accounts with those of manufacturing, a point often omitted in practice though essential to the success of any administrative scheme.

The latter part of the book explains how the costing system should be used to obtain the benefit of its records, instructive both to the student and business manager.

Everyone interested in manufacturing administration will obtain much of value from a volume covering so complete a field, embodying the soundest practice, while remaining free from pedantic padding.

Standard Methods for the Examination of Water and Sewage.—American Public Health Association, 126 Massachusetts Avenue, Boston. Price, $1.25. (Reviewed by Joseph Race, City Bacteriologist and Chemist, Ottawa, Ont.)

The present edition of this volume, like that of the second edition of 1912, is divided into three sections—Chemical, which also includes the Physical, Microscopical and Bacteriological.

The chemical and physical methods recommended are the result of co-operation of Committees of the American Chemical Society, the Society of Official Agricultural Chemists, and the American Public Health Association, and are very little different to those of the previous edition. A welcome modification is a definite recommendation for a standard procedure in the determination of the oxygen absorbed by water and sewage in place of the alternative processes given hitherto. The method now adopted—30 minutes' immersion in boiling water—is, perhaps, very little used in Canada, but those who have used active boiling for five minutes would find only minor differences in their results with the new method. Those who have been accustomed to the European method, which, by the way, is again incorrectly reported in this edition by stating that the temperature of digestion is room temperature instead of 27° C., would have to entirely readjust their standards, as digestion at 100° C. often results in the absorption of 100 per cent. more oxygen than at 27° C.

For the detection of free chlorine in water the toluidine method has been adopted and a method given for the preparation of permanent standards. The toluidine process is undoubtedly more generally suitable than the starch iodide test, but in highly colored waters the natural color somewhat simulates that produced by the reagent and may lead to errors.

More definite recommendations might advantageously have been made regarding the quantity of sample to be used in the determination of free and albuminoid ammonia in sewage. Investigations regarding this point made eighteen to nineteen years ago appear to have been overlooked, but those who have made many analyses of sewage have confirmed this earlier work, and realize the importance of endeavoring to use such quantities of samples as contain approximately equal amounts of nitrogen.

The amplification of the chemical section by the addition of paragraphs containing directions for the analysis of chemicals used in water purification is, indeed, a welcome one, and might very well have been extended by the addition of a standard method for testing bleach.

The bacteriological section of the report was prepared in conjunction with the Society of American Bacteriologists, but several additions were made to the committee report on presentation at the Cincinnati meeting in 1916. The additions were in the nature of supplementary tests for the differentiation of fæcal and non-fæcal types of B. coli, but until these have been more firmly established it would probably have been better policy to make them merely tentative and to recommend them for further study. The bacteriological section has been entirely revised, and many paragraphs that contained matter more or less extraneous to the subject of the report have been eliminated. The section is also free from the ambiguities of the 1912 report, and in this respect marks a distinct advance.

The committee recommends the use of gelatin at 20° C. in addition to agar at 37° C. for bacterial counts, and has made important alterations in the procedure for the detection and estimation of B. coli. In 1912 the committee adopted lactose bile as the enrichment medium, and expressed the opinion that this medium was preferable on account of the inhibition of attenuated organisms. The 1917 report goes to the other extreme by adopting lactose broth containing no inhibiting agent

whatever. Whilst plain broth is preferable to the bile medium, which was variable in composition and too inhibitive, it is open to the objection that it yields an excessive number of anomalous results caused by overgrowths. It is exceedingly regrettable that the changes in the standard B. coli medium have always been so drastic as to render it almost impossible to compare present-day results with those obtained in the past, and have to this extent nullified the value of bacteriological records. Even though a method is not all that may be desired, it is often good policy to retain the old method for the sake of the continuity of comparable results, and the conservative policy is the only safe one when there is no guarantee that the revised methods are only ephemeral. Constant revision begets a desire for revision until it becomes a habit, and stability, which is the essence of standard methods, is never obtained. It is to be hoped that the policy of the committee on the B. coli question will be one of masterly inactivity for the next few years.

The committee have apparently not given the attention to McCrady's method for the enumeration of B. coli that it deserves. This is reported as involving complex mathematical calculations, whereas the preparation of tables is fairly simple, and once made they are good for all time. This method is the only accurate one for the examination of individual samples.

The report is pleasing in appearance, free from typographical errors, and should be added to the library of everyone who is interested in the examination of water and sewage.

Differential Calculus.—By H. B. Phillips, Ph.D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal, P.Q. First edition, 1916. 162 pages, 5 x 7½ ins., illustrated, cloth. Price, $1.25 net. (Reviewed by R. L. Hearn, B.A.Sc., Hydraulic Department, Hydro-Electric Power Commission of Ontario.)

Dr. Phillips, in this little book on the differential calculus, has treated this subject admirably from an engineering student's viewpoint. He has covered the differential calculus very clearly and concisely, and has presented it in such a manner that many of the obstacles that the average student encounters in the ordinary treatise on this subject are cleared away.

As the author states in his preface, a few central methods have been taken, and these, in turn, have been applied to a great variety of examples. The object of this is to drill the student in first principles, with the result that he will gain confidence in himself and secure a solid foundation upon which to base the more advanced problems.

Doubtless, the calculus is one of the most powerful instruments the engineer has at his disposal, and one of his greatest assets when he has mastered it. This book will be found a most useful classroom text for engineering students.

Contents: Chap. I., Introduction. II., Derivative and Differential. III., Differentiation of Algebraic Functions. IV., Rates. V., Maxima and Minima. VI., Differentiation of Transcendental Functions. VII., Geometrical Applications. VIII., Velocity and Acceleration in a Curved Path IX., Rolle's Theorem and Indeterminate Forms. X., Series and Approximations. XI., Partial Differentiation. Supplementary Exercises. Answers.

Wharves and Piers: Their Design, Construction and Equipment. — By Carleton Greene, A.B.,C.E., M.Am.Soc.C.E. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1917. 248 pages, 155 illustrations, cloth, 6 x 9 ins. Price, $3. (Reviewed by F. W. Cowie, M.Can. Soc.C.E., Chief Engineer Harbor Commissioners of Montreal.)

In the preface the author states, by way of apology, that the book was written in response to an editorial in one of the engineering journals, calling attention to the lack of American books on the subject of wharves and piers.

A science, or even a principle, of engineering is not limited to America, nor even to New York. The definition of such terms as wet docks indicates that the author's experience and point of view is quite, and only, American. The "requirements of a wharf" would also appear to refer to the considerations applicable to a wharf in New York harbor.

Port authorities and designers in America are, in recent times, coming to understand that a good mixture would possibly result from a compromise of European solidity and permanence with American adaptable, cheaply and more quickly built structures. They would welcome a carefully prepared treatise on modern design and records of successful and non-successful operation.

Before inspiration comes to the originator of a scheme he must be familiar with the features of previous designs and the principles of former practice.

In America, harbor design and construction has not had the vogue of the development of either canals or railways. Competition in transportation has necessitated, in the case of both canals and railways in America, a perfection of routes, permanence of construction and economy of operation.

Canals, unique, majestic, and eminently successful, have added to the name and reputation of the engineer in America. Railways are unquestionably a great success, both as to design and operation. All honor to the foresight of the projectors and capitalists who undertook, to the engineers who designed, and to the builders who carried out the daring and difficult work in a comparatively new country! In both of these types of enterprise the principles of success have been necessity, excellence of design and efficiency of operation.

Can the wharves and piers of North American harbors lay claim to the same records of excellence as compared with similar designs or constructions in other continents and their ports?

The author gives as his opinion that there is a tendency at the present time to slight the advantages of timber construction for wharves and to overestimate those of reinforced concrete. Timber wharf construction may have had its justification when timber, especially oak, was plentiful and cheap, when the successful locations were not sufficiently demonstrated to warrant comprehensive schemes, and when capital for permanent developments was limited. It does seem to be a matter for careful attention as to whether the public in the United States of America will long accept wooden wharves and non-permanent constructions in the greatest port in the world, located in a city whose two great railroads have not hesitated to spend hundreds of millions for their passenger terminals.

If a magnificent and attractive terminal is required by each railroad, how much more an ocean terminal for

the city, characteristic of the success, the wealth and the measure of welcome to the port!

The subject, "Wharves and Piers," is important, almost too vast for one volume. The author has, however, covered with excellent descriptions many important, even essential considerations in the design and operation of, to use the familiar term, "docks," in a volume of 250 pages.

The author is to be congratulated on his publisher. The volume is well bound and the printing and paper are most attractive to the reader, fatigued with the close type and coarse paper of so many present-day technical works. Many paragraphs are well worth reading, even if experience and practice does not permit the reader to subscribe to the ready opinions of the author: "Materials of Construction," "Concrete vs. Timber," "Commercial Life of Wharves and Piers," "Dimensions of Wharves," and "Growth of Ships." Important phases of these essential subjects are discussed, but they are justified by New York arguments, which the author admits have been subject to frequent changes of views.

The chapter on retaining walls is most complete in its description of various types of quay walls and distinctive features of design. "Piers" is the subject of another excellent chapter, where principles of construction and type of design are explained and magnificently illustrated.

In the chapter on "Wharf and Pier Sheds" the function of sheds is to shelter freight and passengers from the elements and to prevent theft of merchandise. "Fire danger," not included, would appear to be a more essential feature than theft. The principle is, however, characteristic of American port designers, who still hold to wooden roofs, doors, floors and supporting docks. One is, therefore, not surprised to read the following sentence: "Unprotected steel frames are sometimes cheaper than those of wood, but do not last as long in case the freight takes fire." In a fireproof shed fire in the goods can usually be controlled, which is not the case when the structure itself adds to the progress of the fire, both above and below.

The chapter on "Fire Protection" is well worth the price of the book, and the automatic sprinkler system, although at high cost, is explained and recommended.

Chapter VIII., "Cargo Handling Machinery," with an appendix on Costs, completes the volume.

Port authorities will welcome "Wharves and Piers," and their libraries will be enhanced in value by the addition of this volume, with another recent publication of similar nature on "Mechanical Handling and Storing of Material," by George Frederick Zimmer, A.M.Inst.C.E.

Elements of Hydraulics. By S. E. Slocum, B.E., Ph.D. Published by McGraw-Hill Book Co., Inc., New York. Second edition, 1917. 329 pages, illustrated, 6 x 9¼ ins., cloth. Price, $2.50. (Reviewed by Willis Chipman, B.A.Sc., of Chipman & Power, civil engineers, Toronto.)

That a second edition of Prof. Slocum's textbook on hydraulics was demanded within two years of its publication early in 1915 is evidence that it was appreciated by the engineers interested in hydraulic work.

In the revised edition the author has improved the typography, numbered the paragraphs for convenience in reference, simplified certain terms, and made important additions to the text.

The first section of the volume is devoted to "Pressure of Water," including applications to accumulators, hydraulic jacks, elevators, pressure on dams, lock gates, etc. The second section, "Flow of Water," presents in a most convenient way various formulæ respecting flow through nozzles, pipes, channels, weirs, etc. The third section on "Energy of Flow," deals principally with motors, turbines and pumps.

The diagrams explanatory of theories are exceptionally clear and the selections of photogravure illustrations have been made with great discernment. In few books on engineering subjects are the cuts and illustrations so interesting and instructive. In some instances, however, the nomenclature in formulæ does not agree exactly with that in the accompanying diagrams.

The hydraulic data and tables comprised in Section 4 are a fitting appendix, and will be found useful for reference.

This volume will be found a valuable addition to the library shelf of the practising engineer.

Elementary Mechanics for Engineers. — By Clifford Newton Mills, B.S.,A.M. Published by the D. Van Nostrand Co., New York. 127 pages, 36 illustrations, 4½ x 7¼ ins., cloth. Price, $1 net. (Reviewed by Prof. Robert W. Angus, Toronto University.)

This little book is written in as simple a manner as possible so as to meet the needs of younger students. The subject has been divided into the three parts, Kinematics, Kinetics and Statics, and the general method of treatment is very similar to that of most other writers on the same line.

The book can be read by persons having a very limited knowledge of mathematics, but the reader would have to understand trigonometry, as an acquaintance with it is assumed and formulæ involving it are used. One of the most valuable parts of the book is the large collection of examples illustrating each point, and typical cases are worked out in detail.

CATALOGUES RECEIVED.

McAvity Corporation Specialties. — Catalogue No. 1004, illustrating World and McAvity Brass Corporation specialties. Twenty-eight pages; well illustrated. Covers hydrants, crane attachments, valves, service boxes, sewer castings, indicator posts, alarm whistles, fire hose nozzles and couplings, sewage pumps, lighting posts, tapping machines, water meters and corporation brass work.

Crushing Rolls.—Thirty-eight page, well-illustrated catalogue of crushing rolls manufactured by the Traylor Engineering & Manufacturing Co. at Allentown, Pa. Nicely printed on glossless coated paper and well-arranged so as to be easily read. Contains much data and information of interest to engineers or others who have rock or ore to crush.

Partial List of Contracts.—Twelve-page and cover pamphlet, printed in colors, issued by the Foundation Co., Limited, giving partial list of contracts successfully completed in Canada by that organization. The list includes 16 bridges, 11 substructures for buildings, superstructures for 2 industrial plants, 4 underpinning jobs, 50 diamond drill boring contracts, and approximately 14 general contracts, including piers, tunnels, shafts, railway stations, freight sheds, dams, docks, hydro-electric developments, etc.

LETTER TO THE EDITOR.

Stone-Filled Sheet Asphalt.

Sir,—Referring to your March 8th issue and the letter printed therein, criticizing the article under the above title that appeared in your February 15th number, your correspondent is mistaken in thinking that the relative slipperiness of standard and stone-filled sheet asphalt surfaces "can be scarcely more than a matter of opinion." That may be true for those who have had little or no actual experience in mixing and laying, and later observing the different bituminous sheet layer surfaces. It is unfortunate to have to base one's judgments upon what may be found in the books upon this subject, for they are but few, and those few are very inadequate.

But it is a matter of known fact that the addition of stone chips to any sheet asphalt surface mixture produces a pavement that is not only less slippery, though "almost as smooth" after the initial roughness has worn off, but that is also harder to mark up, easier of traction, less liable to displacement, and less expensive to make than the mixture not containing the stone-chip filling.

Experiences and tests of the most practical sort, the driving of horses and automobiles almost daily over many such surfaces that we have ourselves constructed, do not result in a "matter of opinion" on the first three points. The fourth is almost self-evident, and supported by the general observations of many; the fifth is easily demonstrated.

The way in which an asphalt surface "marks up" in warm weather is a valuable indication of its quality. Much less marking is compatible with good quality in a stone-filled than in a standard asphalt surface, due to the resistance offered by the fine stone chips dispersed through the former.

While the failure of a surface to "mark up" to a certain degree, dependent upon the type of mixture of which it is laid, is an indication that the asphalt cement is too hard, its acquiring of certain markings does not even prove that the cement is sufficiently soft. There are several other elements that enter into the matter and affect the result materially.

The "marking up" is not a desirable feature. It would be better if pavements that were otherwise all right could be so laid that they would not mark up at all. The advantage gained by the horse in better footing is overcome by the greater tractive resistance of the load on the markable surface. As the pavement cools off, the marks disappear under traffic.

Your correspondent remarks that "This condition, we always believed, was controlled by the filler and the penetration of the bitumen." Well, we had given your readers credit for knowing that much. The hardness produced by stone chips in the mixture, to which we had reference, is additional to any hardness that such mixture may possess from other causes. This additional hardness is much greater than might be thought.

On the matter of cost, your correspondent seems also to be misinformed and uninformed. His price for $\frac{3}{4}$-in. stone is not in reasonable relation to the other prices used; and, in comparing a two-course surface to a one-course surface, he has apparently overlooked the necessity and added expense of laying, raking and rolling the former surface in two courses. He has also charged himself with five pounds too much stone dust, unless he intends to use that in his close binder, which, though not usual, would be very commendable as long as the "bitulithic" people did not object that his "close binder" infringed their patents.

But why compare a two-course to a one-course surface in this instance? The writer recommended that the "binder course be eliminated," and that the "stonefilling be introduced," and then stated that "either change might be made to advantage without the other." Why not compare one inch of binder and one inch of standard surface to one inch of binder and one inch of stone-filled surface? The latter would still be about $2\frac{1}{2}$ cents per square yard cheaper.

Or, if a two-course surface must be compared to a one-course surface, then compare a 2-inch two-course surface to a $1\frac{1}{2}$-inch one-course surface, as these are about the thicknesses that would be thought to be of more comparable values. Also, do not forget to add the additional labor cost for laying the two courses instead of one. The writer, however, would not recommend the laying of the two-course surface, even if it were as much cheaper as your correspondent would make it, as cheapness in first cost is not necessarily economy, and would not be apt to be in this case.

Concerning your correspondent's request to know why stone-filled sheet asphalt is recommended for adoption by "most" cities instead of by "all" cities, the writer must confess that the principal reason is that he does not know "all" cities. Other reasons are that some cities are built on hillsides, some cannot secure stone chips at a reasonable price, and still others are affected by local conditions peculiar to themselves or their geographical districts. There are many variables in the road and street paving problem.

Regarding your correspondent's final facetious remark that he is "from Missouri," the writer is not. Whenever the writer has been unable to "see" what was told him, he has usually proceeded to do his own "looking" instead of waiting to be "shown."

C. A. MULLEN,
Director of Paving Dept., Milton-Hersey Co., Ltd.

Montreal, March 29th, 1917.

NEW LINE OF CENTRIFUGAL PUMPS.

The Bawden Machine Co., Limited, of Toronto have incorporated a subsidiary company called the Bawden Pump Co., Limited, for the manufacture of centrifugal pumps for waterworks, sewage, filtration and industrial purposes, and also intend manufacturing valves and other waterworks specialties, and to supply turbines, engines, motors, etc., for pump drives.

The Bawden Machine Co., Limited, have been manufacturers of boiler feed pumps for many years past, but only recently decided to go into the larger field of centrifugal pumps.

C. N. Schrag, formerly sales engineer in charge of the Ontario District Office of Canadian Allis-Chalmers, Limited, was induced to join the organization as sales manager, and T. M. Jones, designer at Canadian Allis-Chalmers, Limited, as chief engineer and general manager.

Of the quantity of coal and coke produced in England in 1913, over 155,000,000 tons were carried on the railways, compared with 7,135,000 tons by canals.

Editorial

PAYMENT FOR GOOD ROADS.

Under the above title an Ottawa daily newspaper editorially calls attention to the fact that equitable taxation must precede any great expansion of the good roads movement. This is an important point and the Ottawa paper has not laid any too great stress upon the necessity of equitable method of collecting the payment for good roads.

Col. Sohier, the chairman of the Massachusetts State Highway Commission, who attended the Good Roads Congress this month in Ottawa, assured *The Canadian Engineer* that equitable taxation and uniform assessment are vital to the good roads movement if injustice is to be avoided. In Col. Sohier's state, legislation is now being passed which tends to adjust matters of this kind and which will give state aid for maintenance of town roads to the amount of $3 per annum per thousand dollars of valuation on the road. This amount, we understand, applies only to towns of less than $500,000 total assessed value.

The necessity of some such aid for maintenance is shown in the fact that the valuation of property on Massachusetts roads varies from $20,000 per mile to $2,500,000 per mile, the average being about $200,000 per mile. One mill added to the tax rate for maintenance of roads would give Boston $2,500 per mile for maintenance, while it would give some other communities only $20 per mile, and would give the average town throughout Massachusetts only $200 per mile. State aid to the smaller municipalities is evidently a necessity. The same lines of reasoning would apply even more forcibly to the Canadian provinces, nearly all of which are much larger than Massachusetts yet with smaller populations.

In the construction of state roads in Massachusetts the necessity of state aid was shown by the fact that the roads are often nearly as valuable as the towns through which they pass. Twenty-four miles of the Mohawk Trail in Massachusetts goes through three towns whose total assessed valuation is less than the cost of the "trail" that passes through them.

With the growth of the good roads movement in Canada, and with our many sparsely settled communities, the same situation will arise in this country unless liberal provincial and Dominion aid is extended upon some suitable plan. The first step in the plan is equitable taxation.

A little over three years ago the Ontario provincial government appointed a commission to report on the public roads of Ontario. The commission consisted of C. A. Magrath, chairman, W. A. McLean and A. M. Rankin, M.P.P. In concluding paragraphs of this report the commission says, "The good roads movement begins with the assessment roll * * * The subject of good roads is closely associated with questions of taxation and taxation methods.

"Good roads mean money, and money for public purposes must be furnished by the people in one form or another. * * * An examination was made of recent sales in certain registry offices in the province, and then the assessed values of these properties were obtained from municipal rolls. It was found that the ratio of assessment to sale figures varied from 6% to 96%.

"The good roads are to lace together all the townships within the various counties; the people are to be taxed for those roads; the amount of taxation will depend upon the assessment; and if the people within those townships are to be fairly and equitably taxed for such purposes, there should be some method of creating uniform assessments."

INDUSTRIAL CENSUS FOR 1917.

Manufacturers throughout Canada, and all those who have to do business with industrial concerns, will derive satisfaction in the announcement just made by Sir George Foster that a comprehensive census of the industries of Canada will be taken for the year 1917 by the Census and Statistics Office. The period of reconstruction which will follow the war will necessitate the fullest possible data with regard to industrial undertakings of all kinds. Sir George is to be congratulated upon initiating the new census at this time. The figures of the census of 1911 have now become quite useless as a basis for any close estimation.

It is stated that the organization within the Census and Statistics Office has been placed upon a better basis, and that more skilled collectors can be placed on this work than are usually used for the enquiries regarding population, agriculture, etc. Sir George announces that in the future the industrial census will always be taken apart from the census of population and agriculture, and in a different year, so as to equalize the flow of work for the census office and also so as to afford the possibility of better organization with regard to the industrial census.

In the official government announcement it is stated that the enquiry will be the most comprehensive of its kind ever undertaken in Canada, and that the government will co-operate with the various provincial departments and with those of the Dominion departments which have technical experience of industrial processes and conditions. It would undoubtedly be of very great assistance to the census office in this connection if the Canadian Society of Civil Engineers, with its large and well-organized membership, extending throughout all of Canada and including men who are familiar with every phase of industrial development, could be persuaded to assist the census department officially in connection with the gathering of these statistics.

GOOD ROADS INCREASE ACCIDENTS.

In an address before the Dominion Good Roads Congress at Ottawa this month, R. B. Morley, general manager of the Ontario Safety League, said that men recently assigned to observe the conduct of people approaching and passing over railroad tracks, on important highways, turned in some startling statistics in their report. Of 17,000 drivers of motor cars and other vehicles, 3,300 ran at a reckless speed, and 11,815 seemingly did

not care enough for their own lives or the lives of those in their charge to look in either direction to note whether a train was approaching.

We understand that these observations were made at Southern Pacific crossings in California, but that a prominent United States railroad man said that it would be found that these conditions apply wherever a good highway crosses a railroad.

If these figures are true, it is evident that a very extensive campaign of carefulness, or safety education, will have to accompany the good roads movement or else the increase of good roads in Canada will mean a very great increase in the number of fatal accidents.

COMPARATIVE COST OF STERILIZATION BY HYPOCHLORITE AND LIQUID CHLORINE.

Some interesting figures on the comparative cost of sterilization by hypochlorite of lime and liquid chlorine are contained in a paper read a few weeks ago by Mr. M. S. Dutter, before the Illinois section of the American Waterworks Association. The plant from which these figures were obtained was put into operation the latter part of January, 1915. The water supply is taken from a comparatively small stream, and is at all times subject to contamination by sewerage and waste water from coal mines. Two triplex plunger pumps pump the water from a low-lift pump house to the filtration plant, three-quarters of a mile away. The water flows through a weir-box mixing chamber, two coagulating basins, three filter units, and thence to a clear well under the filter house. From this clear well the water flows to another larger clear well, from which the service pumps take their suction. It was at a point between these two clear wells where the application of either liquid chlorine or hypochlorite has been applied. The plant has a capacity of 900,000 gallons per day, and was originally constructed with tanks for applying hypochlorite. In February, 1916, a chlorinator was purchased. Comparing the month of January, 1916, when hypochlorite was used, with June, 1916, when liquid chlorine was used, the following results were obtained:—

	January.	June.
Total pumpage, gals.	10,230,700	8,501,500
Average daily pumpage, gals.	330,000	283,380
Total hypo. used, lbs.	153.2	.....
Total liquid chlorine used, lbs.	.....	12

With hypochlorite at 7 cents per pound and liquid chlorine at 20 cents per pound, the average cost of sterilization by means of hypochlorite was $1.07 per million gallons of water treated and $0.28 per million gallons when using liquid chlorine.

The average reduction in bacteria count of daily plates made on nutrient agar incubated at 37° C. for 24 hours was as follows: In January, when hypochlorite was used, the average raw water count was 6,300 and the filtered water count was 15. In June, when liquid chlorine was used, the average raw water count was 7,980 and the filtered water count was 11. In Bacillus coli tests the raw water shows 100 per cent. for both months, while the filtered water shows 1.6 per cent. in January and 0.0 per cent. in June. These results were obtained by means of 1 c.c. samples in all cases. While hypochlorite was used 0.46 p.p.m. of chlorine was applied and while using liquid chlorine 0.22 p.p.m. of chlorine was applied.

PERSONAL.

Sir HENRY EGAN has succeeded the late Sir Henry Bate as chairman of the Ottawa Improvement Commission.

JAMES STABLES has been appointed chairman of the Vancouver and Districts Joint Sewerage Board, to succeed FRANK BOWSER, who has retired.

R. E. W. HAGARTY, A.M.Can.Soc.C.E., has been appointed engineer with Messrs. MacFarlane, Pratt & Hanley, engineering constructors, in connection with the construction of a 1,000,000-bushel reinforced concrete elevator at Midland, Ont.

R. D. FEATHERSTONEHAUGH, mining engineer of Edmonton, Alta., who is in charge of the development of the Copper Chief mine near Trout Lake, B.C., was caught in a snowslide recently and narrowly escaped death.

E. B. SKEELS, resident engineer of the Lethbridge, Alta., division of the C.P.R., has severed his connection with the company and leaves shortly for Chicago. It is understood Mr. Skeels will identify himself with some other branch of contracting and engineering than railroad work.

Col. J. D. STEWART, who has performed useful service at the front, and has been placed in command of railway construction work for the Allies in France, has also been promoted to the rank of brigadier-general. He is a well-known Canadian railway contractor and a member of the firm of Foley, Welch & Stewart.

GEORGE BURY, vice-president of the Canadian Pacific Railway Co., is now in London, England. He was a member of the Allied Commission to Russia, which was headed by Lord Milner. After the commission left Russia, Mr. Bury remained there for a month at the request of the Russian Government.

Professor BORIS BAKHMETEFF, who it will be remembered delivered a most instructive address before the Ottawa Branch of the Canadian Society of Civil Engineers last October, on "The Russian Engineer and the War," has been appointed vice-minister of trade and industry in the new Russian government.

C. R. RICHARDS, M.Am.Soc.M.E., formerly professor of mechanical engineering, University of Illinois, Urbana, Ill., and head of the department since 1911, has been appointed Dean of the College of Engineering and Director of the Engineering Experiment Station of the University of Illinois, to succeed Dr. W. F. M. Goss, who has resigned to become president of the Railway Car Manufacturers' Association of New York.

Lieut. CONN. SMYTHE, of the Canadian Field Artillery, has won the Military Cross. He is a son of A. E. S. Smythe, of the editorial staff of the "Toronto World," and was in his fourth year at the School of Practical Science, taking a course in civil engineering, when, in March, 1915, he enlisted as a gunner. In the following July he received his commission and he left Toronto with his battery early in 1916.

OBITUARY.

Lieut.-Col. W. W. STEWART, a prominent architect of Hamilton, Ont., has been killed in action.

GERALD LOMER, president of the firm of Gerald Lomer, Limited, Montreal, passed away very suddenly last week. Mr. Lomer was taken ill at his office and died a few minutes after reaching a hospital. He was born in Brooklyn, N.Y., 67 years ago, but was a resident of Montreal for the past 63 years. He was a member of the Engineers' Club.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

SOME COSTS OF SEWER WORK

SEWER WAS BUILT IN THREE SECTIONS—IN TUNNEL, IN OPEN CUT FOR CONCRETE AND BRICK, AND IN OPEN CUT FOR TILE

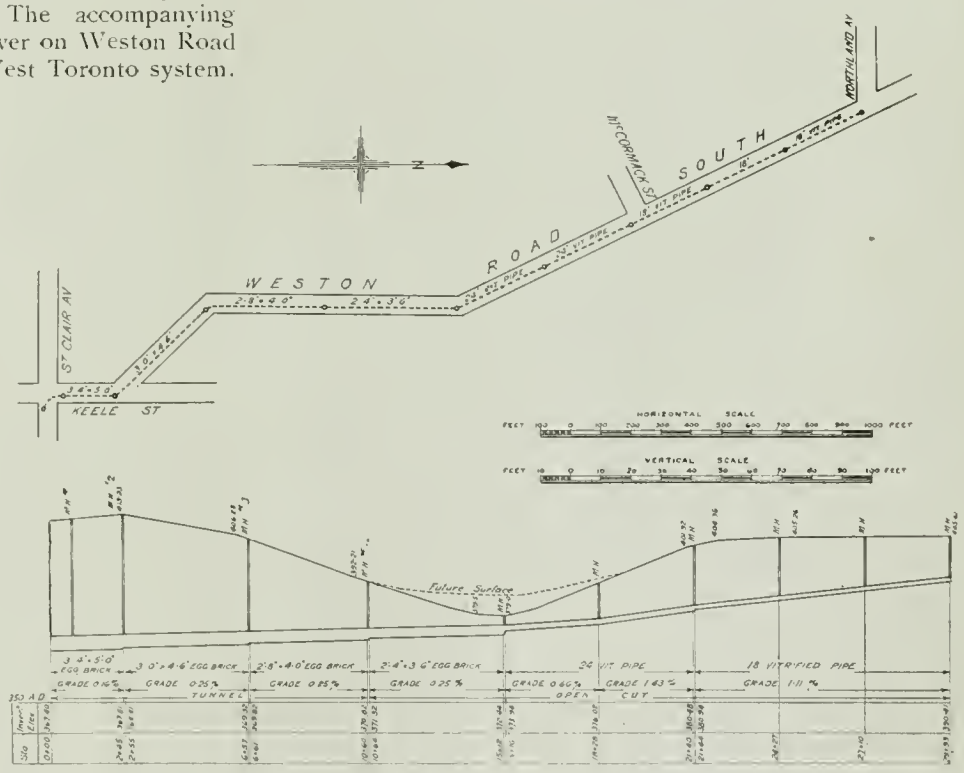
By W. G. Cameron, B.Sc.,
District Engineer, Sewer Section, Dept. of Works, Toronto.

IN former issues of *The Canadian Engineer** a series of articles has appeared dealing with the "West Toronto Sewer System," lately completed at a cost of $2,000,000.

A general sketch of the system was given, a description of the outlet for storm water to the lake and a description of the stand-by tanks where this storm water is separated from the sewerage. Compressed air, which was used extensively in the construction of this system, was also discussed in this series. The accompanying plan will show the location of the sewer on Weston Road South and its connection with the West Toronto system. As will be seen, it serves a part of the abattoir district and discharges into the Woodville Avenue sewer.

This sewer on Weston Road south is interesting, not because of its costliness, nor because of any great difficulty met with in the work, but because it was constructed in three sections. Part of it was built in tunnel, part in open cut for a concrete and brick sewer, and part in open cut for tile pipe, thus requiring a different organization for each part. The accompanying section shows the reason for this division into three parts. As will be noted, the sewer was built in tunnel where it was far beneath the surface of the ground and in open cut where the street dipped down to cross a ravine, bringing the sewer near the surface of the ground. The lengths of these three sections were as follows: 1,054 feet were built in tunnel; 456 feet were built of brick and concrete in open cut; 625 feet were 24-in. and 851 feet were 18-in. tile pipe built in open cut.

The tunnelled portion of the sewer passes through ground which was found to contain water to the depth of about two feet in the bottom of the tunnel. Compressed air was accordingly resorted to in order to drive it out while the work was being done. From three to ten pounds was found sufficient to accomplish this, but owing to the loose nature of the ground, much air escaped and the necessary pressure was both difficult and costly to maintain. The contractors, Messrs. Jennings and Ross, decided to construct the tunnel from the small or head end since it was nearer to the surface. The tunnel was built in three sizes and all from one heading. A single lock was built in open cut at No. 4 manhole, where the tunnel approached nearest to the surface, and so necessitated the minimum amount of excavating. Another lock was built at No. 3 manhole—this one in tunnel. In this case, the shaft was sunk after the lock was built. Seeing that the finished sewer would be small, the inner of the three rings of brick was left out temporarily to facilitate the work. When this inner ring was later put in after the other two rings were completed, a small pipe or hole was left through it every 2½ feet along the crown. When the inner ring had set, grout was pumped in through these holes to fill up the small shrinkage crack which necessarily appeared above the inner ring.



Plan and Profile.

Where the street dips down to cross the ravine shown in the section above, the sewer was, as we have stated, built of brick and concrete in open cut. The ex-

*See *The Canadian Engineer* for March 2, 1916, and August 10, 1916.

cavating was done with the aid of a clam shell. Since the bottom of this trench was wet, a great deal of pumping was required. Part of the sewer in this open cut was so near the surface of the ground that an extra ring of brick was provided, and at the nearest point to the surface a 6-inch concrete covering was also provided.

For the 24-inch and 18-inch tile pipe sections of this sewer, the excavating was done in stretches of open cut and tunnel alternating; or, say, a 12-foot stretch of open cut and then 8 feet of tunnel. The space remaining above the sewer in the tunnelled stretches was packed with 1:4:9 concrete. These short stretches of tunnel saved a great deal of handling of excavation.

A fair line of costs was kept on this job, and we shall endeavor to give them as clearly as possible. Of course, they do not include overhead charges, depreciation of plant, cost of bond or wastage of tools, etc. In the costs is given separately the cost of the tunnelled section, open cut section, 24-inch tile pipe, 18-inch tile pipe, lining, building one lock, setting up compressor plant and building Nos. 1, 2 and 3 shafts and manholes.

Intersections of Weston Road South Sewer with that on St. Clair Avenue.

Tunnel Section, Weston Road South.

Ground wet in lower 2 feet only, compressed air used. Sizes, 3 ft. 4 ins. x 5 ft.; 3 ft. x 4 ft. 6 ins.; 2 ft. 8 ins. x 4 ft. 1,054 feet of tunnel.

Item	Total Time	Total Material	Unit	Cost
Foreman	200 days	1,812 cu. yds	0.11 days /c. yd	$ 800.00
Comp. Engr.	1,626 day hrs.	1,812	0.90 hrs.	1351 70
Pump "	1,600 night hrs.	237,000 hr.	6.71 " /1 000	
Team Brick	1,895 hours	1,812 cu. yds.	1 046 " "	758 00
" Plant	145 "	237,000 br.	0.61 " /1,000	98.10
" Surplus	201 "	1,054 lin ft.	0.9 " / ft.	135.97
" Misc.	464 "	1 812 cu yds.	0.26 " /c. yd.	309 35
Miners	22 "	1,054 lin. ft.	" / ft.	4.65
Muckers	1,929 "	1,812 cu. yds.	1.065 " / yd.	964.50
Tagman	2.297 "	1.812 "	1.270 " "	803 95
Brick haul	1,478 "	1,812 "	0.816 " "	443.40
Bricklayers	533 "	237,000 br.	0,290 " /1000	159 90
" labor	1,574 "	237,000 "	5.80 " "	1442.70
Labor, Misc.	6,556 "	237,000 "	27.64 " "	2,094.60
" Cl'n'g Sewer	708 "	1,054 lin. ft.	0.66 " /1 ft	212.40
Labor, Pumps	811 "	1.054 "	0.77 " "	244.30
" Plant	136 "	1.054 "	0.13 " "	40 80
Watchman	337 "	1.054 "	0.32 " "	101 10
Cement	43 days	1,054 "	" "	86 00
Brick	2,449 bags	1.054 "	" "	979.60
Prickpackers	237,000	1.054 "	" "	2,607.00
Sand	28.000		27 0	308 00
Lumber	275 cu. yds.			412.50
			8.00 B.M. /l. ft.	100 00
			Total Cost.....	$12.767 52

Cost per foot of sewer (tunnel)	$15.02,	with air	$15 02
Total cost brickwork, in place per 1000 (in tunnel)	40.50,	" "	42.00
Total cost mining /c. yd. / tunnel	1 63.	" "	3.05
" " compressed air / l. ft.	3.00		

Weston Road South—Shaft and Manhole No. 1.

Sand; 39 ft. deep, 8 ft. x 10 ft.

Item	Time, etc.	Volume	Unit	Cost
Foreman	13 days	112 cu. yds.	0.12 days /c.y.	$52.00
Engineer	69 hours	112 "	0.610 hrs. / "	27.60
Team	60 "	112 "	0.536 " "	39 80
Excavation	251 "	112 "	2.241 " "	75.30
Timber	77 "	112 "	0.689 " "	23.10
Backfill	92 "	72 "	1.278 " "	27 60
Moving Plant	156 "	112 "	1.393 " "	46.80
Bricklayer	49 "	11,000	4.455 " /1,000	36.75
" labor	210 "	11,000	19.091 " "	63.00
Brick	11,000	117 bags cement		121.00
Cement	117 bags	112 cu. yds.		46.80
Sand	13 cu. yds.	112 "		19.50
Lumber				30 00
				$609.25

Total cost of brick in place, $28.82 per thousand.

Lining.

The third or inner ring of the 2 ft. 8 ins. x 4 ft. was left out and built after the tunnelling was completed.

Item	Time, etc.	Volume	Unit	Cost
Foreman	10 days	27,100	0.37 hrs. /1,000	40.00
Bricklayer	335 hrs	27,100	13.36 " "	117.25
" labor	579 "	27,100	58 26 " "	552.65
Cleaning	46 "	27,100	1.70 " "	16.10
Team	26 "	27,100	0 96 " "	9.10
Brick	27,100	325	83 /bag	298.00
Cement	325 bags	27,100		130.00
Sand	36 cu. yds.			54.00
	Total brick -	27,100		$1,217.10

Total cost of brick lining in place, $44.91 per 1,000.

Weston Road South—Shaft and Manhole No. 3.

Sand; 31 ft. deep, 10 ft. x 14 ft.

			Unit	Total Cost
Foreman	11 days	160 cu. yds.	0.07 days/ c.y.	$ 44 00
Excavation	480 hrs.	160 "	3.00 hrs. "	144 00
Timbering	128 "	160 "	0.80 " "	38.40
Backfill	36 "	80 "	0 35 " "	10.80
Team Surplus / Moving Plant	83 "	80 "	1.04 " "	55.35
Moving Plant	180 "	160 "	1.14 " "	54.00
Engineer	64 "	160 "	0.40 " "	25.60
Bricklayer	60½ "	7.050 "	8 64 " "	45.35
" labor	187½ "	7,050 "	26.80 " "	56.25
Concrete	67 "	5 "	13 40 " "	20.10
Cement	96 bags			38.40
Sand	11 cu. yds.			16 50
Brick	7.047			77.00
				$625 75

Shaft and Manhole No. 2.

39 ft. deep.

			Unit	Total Cost
Foreman	16 days	324 cu. yds	0 05 days/ c.y.	$ 64.00
Engineer	249 hrs	" "	0.77 hrs. "	99.60
Fireman	185 "	" "	0 57 " "	64.75
Pumps (labor)	34 "	" "	0.105 " "	11.90
Team (D R.)	195 "	224 "	0 87 " "	130 00
Excavation	1,127 "	324 "	3 48 " "	450.80
Timbering	170 "	324 "	0.525 " "	80.00
Backfill	341 "	100 "	3 41 " "	119.35
Concrete	47 "	5 "	9 40 " "	16.45
Bricklayer	174½ "	16,400	10 64 " 1000	130.70
" labor	531 "	16 400	32.40 " /1000	185 85
Miscellaneous	34 "	324 "	9.105 " /c.y.	11.90
Brick	16,400			181.00
Sand	22 cu yds.			33 00
Cement	193 bags			77.20
			Total Cost.....	$1,644.50

Total cost of brickwork in this shaft, $35.53 per thousand, in place.

Weston Road South—Building Locks and Setting Up Compressor Plant.

Foreman—Locks	10 days	@	$4.00	$ 40.00	
Comp.	11 days	"			$44.00
Engineer—Locks	55 hrs.	@	.40	22.00	
Comp.	80 "	"			32.00
Fireman—Locks	60 "	@	.35	21.00	
Comp.	30 "	"			10.50
Carpenter—Locks	54 "	@	.40	21.60	
Comp.	10 "	"			4.00
Team—Locks	39 "	@	.66⅔	26.00	
Comp.	39 "	"			26.00
Excavation—Locks	178 "	@	.30	53.40	
Timbering— "	30 "	@	.30	9.00	
Backfill— "	200 "	@	.30	60.00	
Engineer—Pump	102 "	@	.40	40.80	
Watchman—	8 dys.	@	2.00	16.00	
Labor Pump	30 hrs.	@	.30	9.00	
Labor Concr., Locks	226 "	@	.30	67.80	
Moving—Comp.	981 "	@	.30		294.30
Cement—Locks	162 bags	@	.40	64.80	
Sand— "	13 cu. yds.	@	1.50	27.00	
Stone— "	30 "	@	2.00	60.00	
Cement—Comp.	82 bags	@	.40		32.80
Sand— "	9 cu. yds.	@	1.50		13.50
Stone— "	15 "	@	2.00		30.00
			Single Lock	$536.40	$503.10

Open Cut—Weston Road South.

Sandy Loam; Length, 456 ft.; Depth, 13.4 ft; Width 6 ft.

Unit	Total Time	Total Volume	Unit	Total Cost
Foreman	61 days	1,390 c. yds.	0.045 days /c. yds.	$ 244.00
Watchman	61 "	1,390 "	0.045 hrs " "	122.00
Engineer—hoist	425 hrs.	1,390 "	0.315 " "	170.00
" —pump	614 "	1,390 "	0.455 " "	245.60
" —moving				
Plant	50 "	1,390 "	0.040 " "	20.00
Fireman	270 "	1,390 "	0.200 " "	94.50
Labor, Pump	80 "	1,390 "	0.060 " "	24.00
Excavating	2,967 "	1,390 "	2.200 " "	890.10
Timbering	276 "	1,390 "	0.205 " "	82.80
Backfill	998 "	742 "	1.345 " "	299.40
Surplus	391 "	608 "	0.643 " "	117.20
Concrete	1,028 "	129 "	8.000 " "	308.40
Team D	157 "	608 "	0.260 " "	106.05
Team Moving Q	20 "	456 c. ft.	0.044 " / c. ft.	13.35
Labor "	40 "	456 "	0.088 " "	12.00
Bricklayer	343 "	45,000 br.	7.400 " / 1,000	249.75
" labor	683 "	45,000 "	15.180 " "	204.90
Cement Concr.	685 bags	456 lin. ft.		274.00
Brick	525 "	45,000 "		157.50
Stone	127 c. yds.			254.00
Sand	76			114.00
Brick	45,000			495.00
Forms				50.00
Lumber				300.00
				$4,848.65

Total cost of brick in place, per thousand, $26.54.

The manholes are built 2 ft. 6 ins. x 4 ft. (inside measurement). Manholes Nos. 1 and 2 are built of 18-in. brickwork throughout the bottom 9 ft., while the middle 20 ft. are of 14-in. brickwork and the remainder of 9-in. or two rings.

Weston Road South—24-in. Pipe.

851 ft. South of Northland Street to 635 ft. Further South. Dry Sand and Clay Loam; (Macadam). Length, 635 ft.; Width, 4 ft.; Average Depth, 13.7 ft.

Item	Total Time	Total Material	Unit	Cost in Hours Labor
Foreman	45 days	635 ft. of sewer		
Excavation	3,286 hours	1,275 cu. yds.	hrs. /c. yd.	2.58
Surplus	321 "	152 "	" "	2.13
Timbering	690 "	635 ft. sewer	" /lin. ft.	1.09
Backfill	690 "	1,123 cu. yds.	" /c. yd.	0.614
Concrete (hand mixed)	524 "	75 "	" "	7.00
Team	139 "	152 "	" "	0.91
Pipelaying	214 "	625 feet	" /lin. ft.	0.34
Concrete M.H.	23 "	2 cu. yds.	" /c. yd.	11.50
Bricklayer	23 "	3,500	" /1,000	6.57
Helper	39 "	3,500	" /1,000	11.14
Cement—Joints		83		
Cement—Pipe		300		
Cement—M. H.		49		
Brick		3,500		
Stone		60 yds.		
Sand		45 "		
Pipe				
Junctions				

Concrete, hand-mixed; surplus earth moved at different times, some having to be picked and scraped off road.

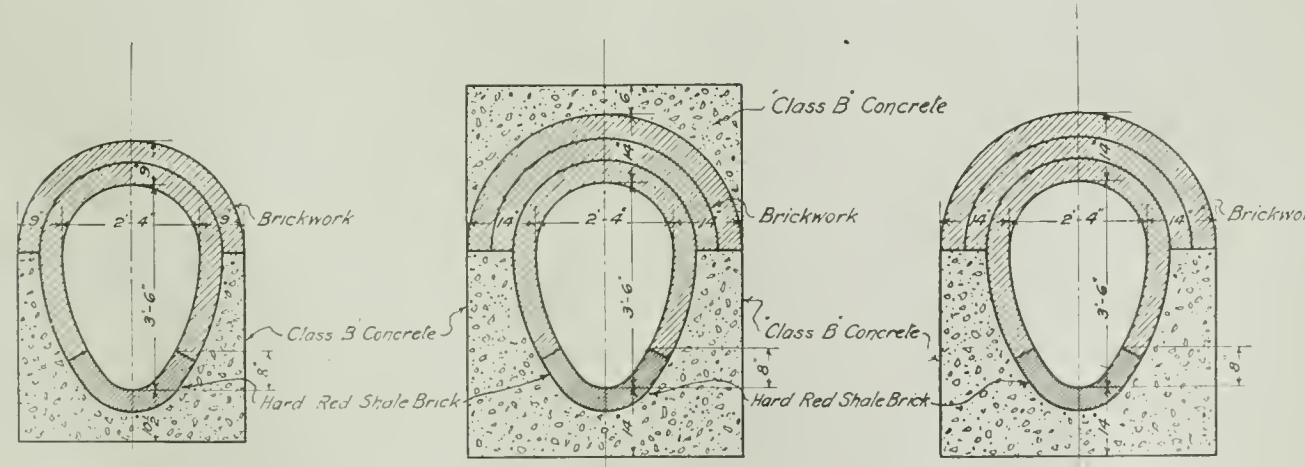
Weston Road South—Northland Street to 851 ft. South. 18-in. Pipe.

Dry Sand and Clay Loam; (Macadam.) Length, 851 ft.; Width, 3.5 ft.; Average Depth, 19.2 ft.

Classification	Total Time	Total Material	Unit	Cost in Hours Labor
Foreman	34 days	851 ft. of sewer		
Excavation	4,776 hrs.	2,118 c. yds.	hrs. /c. yd	2.26
Backfill	1,558 "	1,997 "	" "	0.78
Timbering	1,100 "	851 lin. ft.	" / in. ft.	1.29
Surplus	587 "	150 c. yds.	" /c. yd.	3.91
Team	59 "	150 "	" "	0.393
Pipelaying	315 "	830 feet	" /lin. ft.	0.38
Concrete	725 "	83 c. yds.	" /c. yd.	8.74
Bricklayer	79 "	11,200 br.	" /1000	7.0
Helper	208 "	"	" "	17.70
Cement—Joints		97 bags		
Cement—Manholes		118 "		
Cement—Concrete		374 "		
Brick		11,200 br.		
Stone		71 c. yds		
Sand		54 c. yds.		
Pipe				
Junctions				

Summary of Costs.

Tunnel Section	$12,767.52
Open Cut "	4,848.65
Building Locks	538.40
Setting up Compressors	503.10
Shaft and Manhole No. 3	625.75
" " No. 2	1,644.50
" " No. 1	609.25
Lining 2 8" x 4' sewer	1,217.10
Compressed Air	3,663.56
24" Pipe	3,295.50
18" Pipe	4,873.40
Lumber, Oil, and other Incidentals	1,336.89
Total	$35,323.62



2'-4" x 3'-6" EGG SHAPE BRICK SEWER STA. 10+64 TO STA. 13+80

2'-4" x 3'-6" EGG SHAPE BRICK SEWER WITH CONCRETE COVER STA. 14+20 TO STA. 15+12

2'-4" x 3'-6" EGG SHAPE BRICK SEWER STA. 13+80 TO STA. 14+20.

Sewer Sections.

GOOD ROADS AND LAND DEVELOPMENT.*

By Thomas Adams,
Town Planning Adviser, Commission of Conservation, Ottawa.

ECONOMIC and other practical questions in connection with good roads are not confined to matters relating to construction. While a great deal of money can be lost by extravagance in paving, by using the wrong materials and by want of employing engineering advice in making roads, yet although the fact is not quite appreciated, the direct and indirect loss due to bad planning of roads can be, and probably is, much greater than that which may be due to unscientific construction. Bad planning of a highway system has the effect of increasing costs due to haulage up steep grades and over greater length than is necessary; it causes roads to be laid over hills and across muskegs, creating difficulties in connection with land development and drainage of the worst kind; it has the effect of scattering the population, so that the amount of road surface to be made is entirely out of proportion to that which can be paid for out of any reasonable tax on the people or on the land served by the roads. For the latter reason it causes local authorities to leave roads unmade or to accept the most primitive forms of construction.

Roads should be designed by engineers to save waste in road space as well as in road construction. Above all else our highway policy should be designed to secure the principle of the maximum of convenience at the minimum of expenditure.

When road questions are discussed it is too frequently assumed that it only requires courage and willingness on the part of public administrators to secure a good roads system. As a matter of fact, there is scarcely anything in regard to which more courage and willingness are shown, and the real trouble is not the want of public spirit but simply the want of the available cash to construct roads according to our expensive and wasteful system of planning them. As a matter of fact we do not plan them; we fit them in somehow into a system of rectangular subdivision—either along the concession lines or on a five per cent. basis, which is little better. We should learn to plan our roads for a purpose. There are a few people in favor of good roads because they want to enjoy motoring in the country and a few others who do so because they want to sell road materials or machinery; but the public opinion in favor of good roads which really counts, is that which looks to that means to help in developing the resources of the country. These people want to know how much value the good roads are to the farm, to the factory, to the home; and they are not going to pay more than they are worth no matter how much those who want them from other motives may argue in their favor. Roads are primarily for the purposes of providing access to property, means of developing land, and means of communication for carrying on our industries.

Our roads in Canada are of too great a length, too great a width, and there are too many of them in proportion to the tax-paying capacity of the people, outside of the most thickly populated parts of the country.

Even in the United States, with their greater density of population and with their progressive road policy, they are only able to get satisfactory roads in rural districts by transferring too great a burden of construction to posterity, and then they only get one mile in ten constructed in a satisfactory manner.

According to Mr. Nelson P. Lewis, engineer of the Board of Estimate and Apportionment of New York City, "The State of New York, by the vote of its people, has authorized the expenditure of $100,000,000 for the improvement of the state highways, and this enormous sum is raised by the issue of 50-year bonds. While a portion of the work to be done is undoubtedly of a permanent character, such as the widening and straightening of the roads, the improvement of grades and provision for drainage by substantial structure of masonry or steel, a very large proportion of the expenditure is for road surfaces, many of which can scarcely be expected to last for more than ten years. Borrowing money for fifty years to pay for ten-year roads is obviously unwise."

The only sound principle in financing road improvements is to pay for all construction over the period during which it lasts, and only to borrow money for any longer period, say, up to fifty years, in respect of such portion of the work as is permanent. This permanent portion consists of the matters which may be described as incidental to the planning of the roads, such as, improving the grades by excavation and filling, acquiring a comprehensive survey of every part of a road system before large expenditure is incurred.

Comparisons are sometimes made between the good roads of the British Isles and the poor country roads of this continent. It is only during the last one hundred years that the roads in Britain have become satisfactory, and the greater part of the cost of improvement has been borne during the last twenty-five years. In the eighteenth century the roads in England were hardly passable. We are told that the old Romans used to travel over their highways in Southern Europe at the rate of 100 miles a day, but that in 1703 it took Prince George of Denmark fourteen hours to travel forty miles from Windsor to Petworth. So conservative were the masses of people in Britain against having good roads that in the eighteenth century they resisted their construction with riot and bloodshed, and even when the roads were made and improved, country people in many districts refused to use them. To-day, it is recognized in Britain that the best means of promoting agriculture and the proper development of the land is to have good roads. But the system has to be built up on an economic basis. Those who advise the large land-owners in England consider that there is no better investment than the making of good substantial roads, and that intensive farming cannot be carried on without them; but they only make the roads that are absolutely necessary and do not make reservations round the farms, as if by merely making the reservations they *ipso facto* created roads. Unfortunately, in Canada we have had no proper plan of our road system prepared; the rectangular lay-out of land is entirely meaningless from any other purpose than that of securing accurate measurement of the land for which purpose it is well adapted.

Human necessity, the traffic requirements of the whole population and the relative cost of development to the value of the land and other property developed, should be the guiding principles in laying out a system of roads and streets. Considering the enormous expenditures required to be incurred to improve roads, their economic and social value, the importance of directness of route, the danger and inconvenience of sharp curves and the advantage of easy grades, it is extraordinary that our stereotyped rectangular system pays no respect to either of these questions, except insofar as it does so by accident. The money that is spent by highway departments has to be allocated without the engineer having any voice in the

*Paper read before 4th Canadian and International Roads Congress, Friday, April 13th, 1917.

location of the roads or in their original plan. Even with all the knowledge we have on this subject we split highway administration between colonization departments and ministers of highways so that our highway departments have to finance a system which they have not designed. As a concrete instance of the saving which can be effected in planning a single piece of road the "Municipal Journal" of America draws attention to a road at Cape Cod, Mass., where the estimate of cost varied from $14,000 to $36,000. The layman, without the assistance of the engineer, guessed within 61 per cent. of the actual cost, the engineer, without special examination, guessed within 39 per cent. and after a proper study he arrived at approximately the true cost. What, however, is really more important is that he reduced the cost by 25 per cent. by planning a more economical location.

The moral in this is not only that preliminary plans of roads should be made by competent engineers in the interests of economy, but that the engineer should have the power to exercise discretion as regards location of the road.

As the County Roads Board in Australia said in their report of 1914, "Badly located and badly laid roads are a constant tax on any community." No matter what the construction, they increase the cost to maintain and determine the amount of load to be carried. We all recognize that well-planned and well-made roads would help to build up manufacturing industries, cheapen production and reduce the cost of living by bringing the farmer nearer the consumer. Incidentally it would make it easier for the motorist to get about the country, but he is only a secondary consideration. Good roads would also attract settlers to areas that must remain unsettled without them. But in order to get good roads within the paying capacity of the people we will have to be less extravagant in regard to the width of all secondary roads; and in order to be more liberal in regard to width of the main thoroughfares we will have to be less wasteful in regard to second and third-class roads and streets. We simply cannot raise the money to make our present road and street system efficient, and the 66-ft. minimum in this province is an economic absurdity. When we lay out roads we should do so on a practical basis.

Roads should be planned, designed and constructed, as a rule, to suit the particular form of land development to be served by them. They should be made with due regard to the best use to which the land can be put. Provincial aid should be confined to improving the principal lines of communication. The system of planning highways in country districts determines the street system of the city; but we do not attempt in designing the one to consider its effect on the other.

The actual cost of a street 66 ft. wide, including a 9-in. sewer, a street pavement of asphalt on concrete foundation 28 ft. wide, two cement sidewalks each 5 ft. wide and 28 ft. of boulevard in Ottawa in 1916 was $27.50 per lineal foot. Thus, for a 25-ft. lot the cost of local improvements alone amounts to $343.75. If the cost of land is added it means that $700 to $1,000 has to be paid by the working man for a properly improved lot in a city area.

Owing to their more economic method of planning, widths of streets and frontages of lots, in England, e.g., a working man can obtain a site for a home, including local improvements, on a street 36 ft. wide for $214 as against $725 in a similar location in Canada. Allowing for the difference in the value of the dollar in both countries, the cost is even then from two to three times as much in Canada.

Narrow minor streets, in residential and rural areas, enable wide thoroughfares to be secured where they are wanted; they enable more air space to be given to the buildings,—although one of the reasons for making a wide minimum is for the purpose of giving the buildings air space in the street instead of from the space reserved on the lot; they enable a highway system to be developed on the only sound basis, namely, that the cost of building up the system shall not exceed the ability of the people served by it to pay for it. But there is no particular virtue in the wide street or the narrow street—the only virtue is in planning all streets to adapt them for the purpose they can best serve in connection with the development of land, and above all with due regard to the economic relationship between the value of the land and other property they serve, and the cost of the road or street. Excessively wide streets cause overcrowding—although they are designed to prevent it.

Until we have a properly planned system of highways adapted for all purposes, and economically sound, we will not be able to deal effectively with bad land development in town and country, and we will only be able to go on dealing with the improvement of roads in a sporadic and haphazard manner—good enough in its way and a satisfactory advance on the past, but far short of the ideal which we should seek to attain, and costly and wasteful in the extreme.

The want of a properly designed system of highways is one of the chief causes of the social isolation in rural districts, of lack of co-operation and of development of rural industrials. It is more correct to say that rural prosperity and increased production depend on a sound economic system of road planning than to say that those things depend on good road construction, for the simple reason that good road construction can only be widely applied if we alter our system of planning.

CANADA BUILDING STEEL AND WOODEN SHIPS.

Orders have been placed for steel ships in Canada up to the full limit of all steel plants available during the next fifteen months. The question of developing wood shipbuilding in Canada has been under investigation during the last month. It has been presented to the imperial government that substantial tonnage of suitable wooden vessels could be obtained. The Dominion government, in order to assist the development of shipbuilding in Canada, Finance Minister Sir Thomas White has offered to find credit to the extent of $10,000,000 for the Imperial Munitions Board for this purpose. This offer has been accepted and will greatly facilitate progress. Specifications and designs of the type of wooden vessels required have been under discussion between the board, representatives of the British ministry of shipping and various shipbuilding people. They are now almost complete, and will be available as the standard pattern of design. It is hoped to begin work on vessels of this type very shortly and the building of a considerable number will be arranged for in Canada, where suitable lumber is available in abundance.

Sir Thomas White stated in the House on Monday that orders have been placed by the imperial government for the construction of 22 steel vessels, with a total tonnage of 175,000, with Canadian shipyards, while orders for eight others are pending. This will keep all Canadian shipbuilding plants busy until well into 1918.

James Whalen, president of the Port Arthur Shipbuilding Company, has announced that contracts have been secured by the company for work totalling more than five million dollars. The capacity of the local plant is being doubled, and even at the work now in hand will keep it busy until well on into 1918.

RAPID TRANSIT RAILWAYS—SOME FEATURES OF CONSTRUCTION AND COST.*

By Ernest V. Pannell,
Electrical Engineer, British Aluminium Company, Toronto.

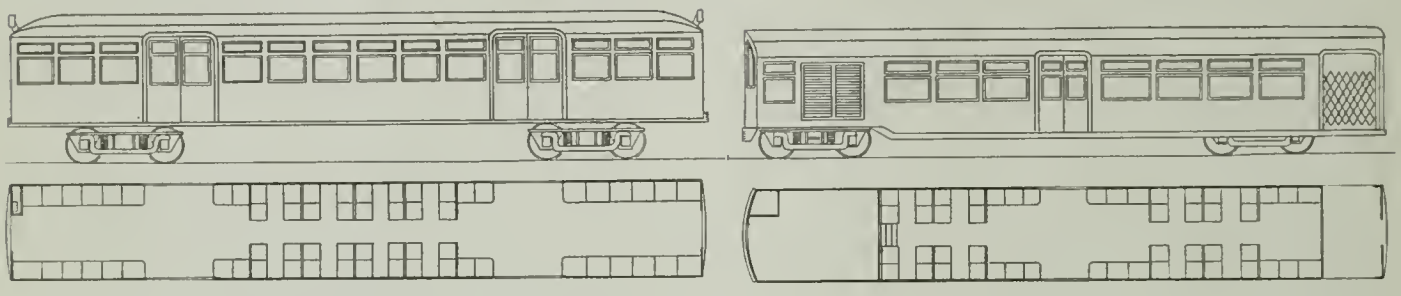
With the growth of population there is a stage in the development of every city where the daily travelling personnel can no longer be handled by the street railways. It is quite impossible to state any figure for population at which an urban rapid transit system must necessarily relieve the surface railways; for instance, the Boston Rapid Transit was operating its elevated lines and part of the subway when the inhabitants numbered little more than half a million, whilst in London, England, the population reached six millions before a unified electric rapid transit system was inaugurated. The width and disposition of the downtown streets, the layout and general efficiency of the street railway system, the size and speed of the cars, are all factors which, if favorable, will tend to defer the construction of rapid transit lines. Nevertheless, in matters of this kind it is necessary to plan many years into the future and preparations should be made for rapid transportation methods many years before the need for them is acutely felt. In view of the many millions of dollars now being expended on rapid transit projects it was thought interesting to summarize the principal costs of construction and equipment of rapid transit lines of various types. It is, of course, hardly necessary to mention that these costs are only intended as a rough approximation, such items as subway excavation, underpinning, etc., being different in every locality. The costs are mainly figured upon contracts placed during the last two years, but do not, of course, allow for the abnormal conditions prevailing at the present moment, particularly in reference to steel and labor.

*Paper read before the Toronto Section of American Institute of Electrical Engineers, April 20, 1917.

There are three systems of construction for rapid transit railways in cities and it will be interesting to compare these in detail. They are: (1) Elevated structures, (2) subways, and (3) tubes. The elevated railway, although less popular than the other types, provides the greatest return per dollar invested and is therefore worth very careful consideration in every locality. The earliest elevated roads in Manhattan and Chicago were objectionable from being erected in narrow streets and with an open floor. The open-floor elevated road in which it is possible to see the underside of the cars from the street beneath gives rise to a great deal of noise and discomfort due to hot brake shoe particles, water, etc., dropping into the street. It has since been demonstrated, notably in Philadelphia, that a concrete-floor elevated road with ballasted tracks is perfectly unobjectionable except in narrow and busy streets and the noise produced is less than that of the street cars below. In European cities, too, every opportunity has been taken to render the elevated railway as sightly as possible. The ground beneath is turned into a parkway and supplied with benches whilst the floor of the road, being of concrete and sheet steel, affords protection against rain to those walking beneath.

The subway next demands consideration and in comparing it with the elevated it should be remembered that each has exactly the same capacity, track for track. We shall find that the subway costs a good deal more, but in respect of handling traffic it is just as good and no better than the elevated road operating the same cars with the same headway and schedules. The extra cost of subway construction is therefore only justified where it has to be used. For example, in Lower Manhattan or Market Street, Philadelphia, the conditions do not permit of elevated structures, and subways in locations such as these are inevitable.

Subways, as at present being constructed in New York, are of steel beam construction with concrete floor and retaining walls. The excavation is through clay and

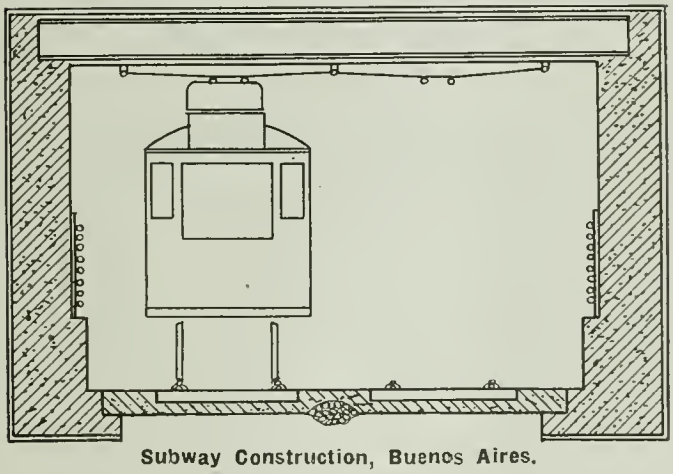


DETAILS OF MOTOR CARS AND EQUIPMENT FOR ELEVATED, SUBWAY AND TUBE SERVICE

	Elevated and Subway	Tube Motor	Tube Trailer
Length of Car	60' 0"	55' 0"	55' 0"
Width " "	8' 6"	8' 2"	8' 2"
Weight Body	45000 lb	32000	32000
" Trucks	26000	25000	12000
" Equipment	14000	18000	-
" Total	85000	75000	44000
Capacity, seated	64	50	56
" total	180	120	135
Weight loaded	111000	92000	63000
Motors per car	2 x 120 KW	2 x 200 KW	-
Rated KW per ton	4.3	4.3	-
Cars per train	5	2	3
Cost per car	16000	14000	8500
" " train	80000	53500	
" " passenger	89.00	83.00	

sand with outcrops of rock according to the district. The chief difficulty met with is in excavating through quicksand which, owing to the great weight of the surrounding buildings, persists in pouring up into the subway and necessitates the retaining walls being carried to a considerable depth below the floor of the tunnel. Underpinning of building foundations is another heavy item in the cost of construction. Subways are excavated by the cut and cover method, but civic ordinances usually require the street to be timbered and made safe for the ordinary traffic to proceed during excavation. This means that hand labor only can be used and mule trains will be necessary for bringing the muck away from the heading. Appropriation of cellars and the re-location of sewers, telephone and power cables is a necessary preliminary work which must be completed before construction proper is begun.

Figs. 1 and 2 show diagrams of typical steel-beam subways in Buenos Aires and Hamburg respectively. The former is part of the new rapid transit development of Buenos Aires and runs through the heart of the city from Plaza Mayo to Plaza Once, a distance of 2½ miles, the construction being now under way for a further 2½-mile



Subway Construction, Buenos Aires.

extension to Caballito, where the subway cars come up to the surface and continue the journey along the highway to the more remote suburbs. The line now in operation involved the excavation of 527,000 cubic yards in alluvial clay or "tosca" and the use of 98,000 cubic yards of brick masonry and 13,000 tons of steel. Brick masonry is used practically to the exclusion of concrete, probably because all the cement used has to be imported whilst the brick is a local product. The cost of construction on this line amounted to $2,680,000 per mile of double track.

The Hamburg subway, opened a few years ago, is part of a suburban system of which 3.41 miles is elevated 10 miles on the surface on private right-of-way and 4.15 miles underground. The construction is steel beam with steel bents in the centre of the tunnel and concrete retaining walls. Construction costs figured out at $1,000,000 per mile of double track and it is interesting to compare this extremely low cost with the figures prevailing in America of $2,250,000 to $3,000,000 per mile of double track.

Reinforced concrete for subway construction has been employed with success, notably in the Boston Boylston Street subway and in New York for the Hudson and Manhattan Railway.

The third type of construction is the deep level tube, which is preferable in some locations to the shallow subway. In London, England, where this line has been the furthest developed, the necessity of crossing under the River Thames as well as the existing underground railways and sewers was the main factor influencing the adoption of tubes. Added to this the presence of the blue clay belt from 40 to 200 feet below the street surface rendered it possible to mine by the use of a shield without blasting or any interference with the surface except at the shafts. The clay contains little rock or water-bearing strata; other locations are not so fortunate as London in this respect, however, and it is doubtful whether tubes could be driven through a subsoil like that of Toronto. In New York the deep level tube is economically impracticable except for river crossings on account of the rock and quicksand which would be encountered.

The depth at which the London tubes are driven, 60 to 200 feet below the street, is such as to cause no interference with foundations, and where necessary the railway cuts across a block instead of following the alignment of the street above. The method of shield construction forms a constant support to the soil above and little or no timbering is used. The shield consists of a steel cylinder about six feet long and the same diameter as the outside of the tunnel segments. The front of the shield forms a cutting edge and the back is provided with seven or eight hydraulic rams around the circumference. These rams obtain their purchase on the last tunnel segments bolted into place and drive the shield forward at the rate of about ten feet per day when working in clay. In the cover afforded by the shield the heading is driven and earth excavated by hand or by a compressed air excavator. Behind the shield as the work progresses the muck is run out along a tram line and the cast-iron tunnel segments are bolted into place. Afterwards the space outside the segments is filled with cement grout pumped through holes in the casting, thus protecting the segments from rust and decay by the elimination of air spaces.

The foregoing has briefly summarized the methods adopted in building railways of the three types.

Table I.—Average Length of Run on City Rapid Transit Systems.

Railway.	Stops per mile.	Average run, feet.
Buenos Aires subway	3.10	1,690
North Western Ry., London...	1.20	4,400
District Railway, London	1.50	3,500
Inner Circle, London	2.10	2,510
Central London, London	2.10	2,510
South London Elevated	1.20	4,400
Interboro' Subway, New York.	2.40	2,200
Berlin Elevated	2.00	2,640
Hamburg Elevated	1.90	2,780
Average	1.95	2,700

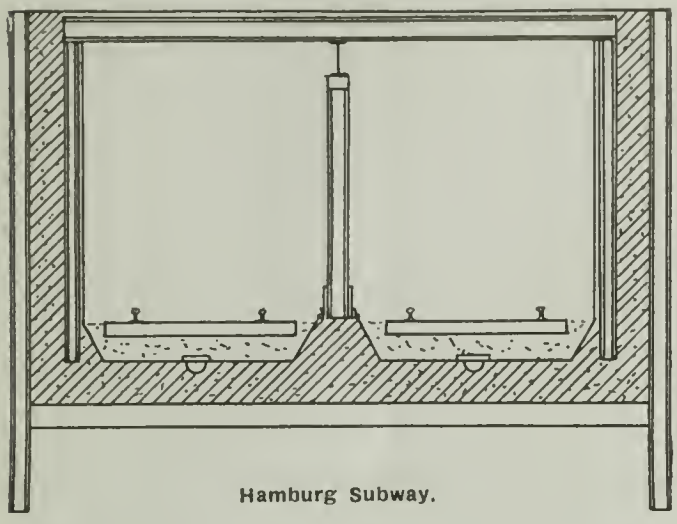
Summarizing the costs, the investment per mile of double track for construction alone is:—

Elevated railway	$ 632,500
Subway	2,500,000
Tube	2,550,000

The above figures are purely construction costs; that is, they are quite independent of the traffic. The railway will cost just as much to build whether one or one thousand trains run over the mile of double track in a day. We have now to estimate and add to the above amounts the cost of the equipment of the road; that is, the cars, feeders, substations, shops and other items

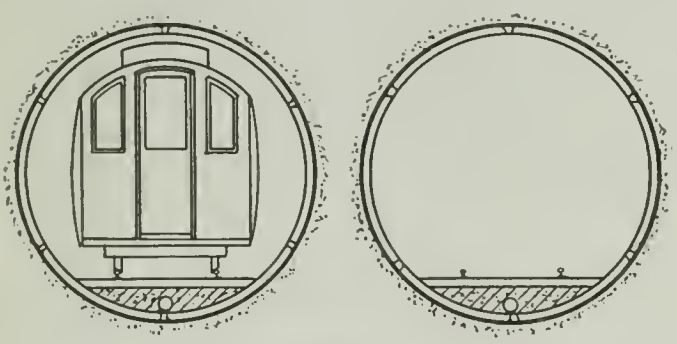
which are all dependent on the number of passengers carried.

The cars illustrated in this study for elevated and subway operation are typical of the more recent rapid transit practice without being quite as large as those now employed by the Boston Rapid Transit and the New York



Hamburg Subway.

Municipal Railways. Cars 70 feet long and 10 feet wide require so much extra clearance, especially at curves, that a much more expensive subway is necessary to accommodate them. The car illustrated, which is of a more normal type, is 60 feet long and 8½ feet wide, seating 64 passengers at the rush hour and carrying 180 in all. The weight of the car fully equipped but empty is 80,000 lbs., whilst loaded with 180 passengers it weighs 105,200 lbs. Its equipment consists of two 600-volt motors rated at 120 kw. each fully ventilated and multiple unit control, and the standard train is of five cars capable of carrying

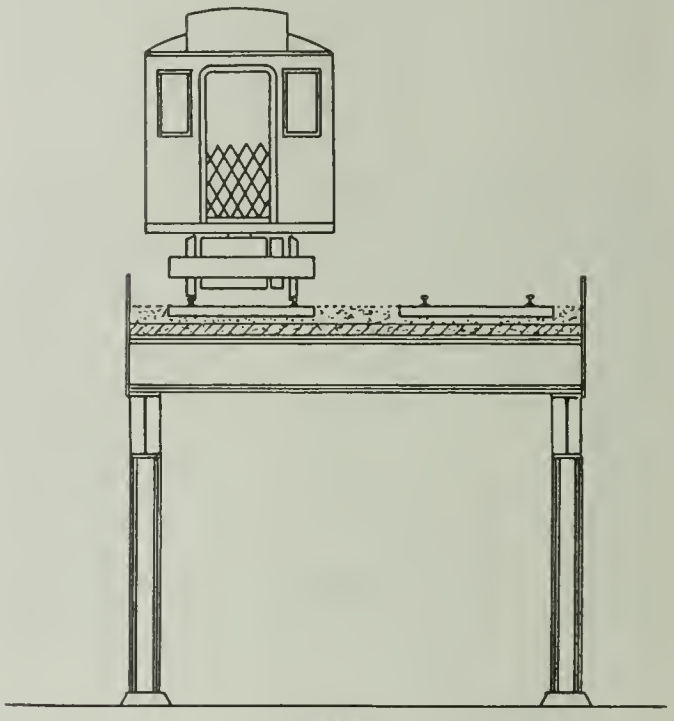


Tube.

Contract.	Quantity.	Unit price.	Cost.
Sinking shafts, excavating with shield, placing tunnel segments, grouting and finishing	..	....	$2,000,000
Track, roadbed and third rail	..	....	100,000
Stations, including elevators and fans	2	....	100,000
Repairs to roadway	..	....	20,000
Engineering and interest 15%	..	....	330,000
Total cost one mile double track tubes	..	....	2,550,000

a total of 900 passengers during the rush hours. Such a train as already mentioned can operate over elevated or subway tracks indiscriminately.

Turning to the tube car it will be seen that the capacity and weight are both lower than the above. Moreover, as mentioned before, space considerations permit of only the leading and trailing trucks of the five-car train being used to carry motors. In order to maintain the same schedule speeds as the subway train the rated kilowatts per ton must correspond with the figure 4.3 and to obtain this the four motors must each be of 200 kw. rated capacity. This involves certain disadvantages. For one thing, the weight of the train is largely concentrated on the leading and trailing trucks which is liable to throw more wear on the track, particularly at curves, than where the weight is more distributed. Secondly, motors of such heavy output for mounting beneath a car have to be of such compact design that full ventilation is not possible and there is not such a wide margin of power for emergencies. Furthermore, as already noted, the carrying capacity of the tube train per ton of gross weight is lower than that of the subway, consequently with the same speeds and headway the tube will be able to transport fewer passengers although its cost of construction is the



Elevated.

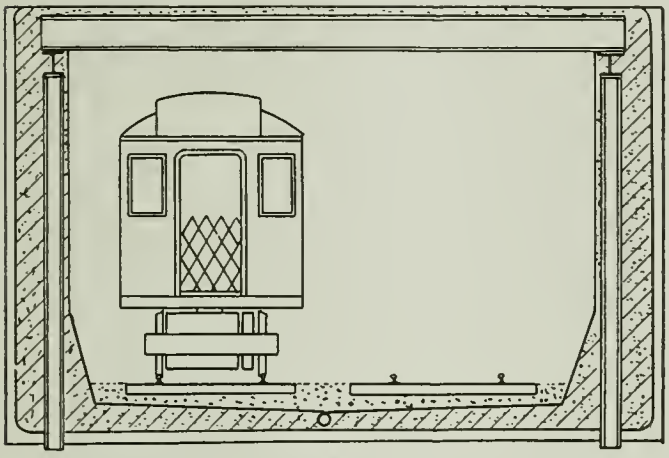
Contract.	Quantity.	Unit price.	Cost.
Structural steel	3,000 tons	$ 80.00	$240,000
Concrete footings	1,000 c.y.	10.00	10,000
" floor	5,000 "	5.00	25,000
Track, roadbed and third rail	.....	....	100,000
Stations	2	25,000	50,000
Repairs to roadway	.....	....	25,000
Property damage	.....	....	100,000
Engineering and interest 15%	.....	....	82,500
Total cost one mile double track, elevated	.....	....	632,500

same or slightly higher than that of a subway. It may be said, however, that the tunnel need not be limited to a 12-foot bore; why not drive a 16 or 20-foot tube and obtain greater capacity? The answer is, of course, prohibitive cost. Approximately the cost of a tube tunnel increases as the 3/2 power of the diameter whilst the capacity is only directly proportional to the bore, so that the satisfactory economic limit for the latter is found to be around 12 feet and by far the greater mileage of tube railways are 12 feet inside diameter or less.

The diagram showing the outline features of the two forms of car also shows the seating arrangements and it will be noted that a large proportion of the floor area is

given over to standing space. This is in accordance with the most approved practice; it is accepted that a number of those travelling at the rush hours will have to stand up in the cars and the latter are so designed that they can stand comfortably rather than the alternative of providing the car with as many seats as possible and reducing both capacity and comfort.

Every railway has a certain tributary population who use the line regularly. Where only one railway system



Subway.

Contract.	Quantity.	Unit price.	Cost.
Excavation	275,000 c.y.	$ 4.00	$1,100,000
Concrete	50,000 "	7.50	375,000
Brickwork	1,000 "	15.00	15,000
Structural steel	3,000 tons	80.00	240,000
Waterproofing	40,000 sq. y.	.50	20,000
Track, roadbed and third rail	.....	....	100,000
Stations	2	....	50,000
Relocating sewers, etc.	.....	....	50,000
Underpinning	.....	....	125,000
Repairs to roadway	.....	....	100,000
Engineering and interest 15%	.....	....	325,000
Total cost one mile double track, subway	.....	....	2,500,000

exists serving all parts of a city the tributary population corresponds practically to the total inhabitants of the city. Where other means of transit exist the tributary population of each has to be calculated, usually upon a basis of time-saving on the assumption that the traveller chooses the quickest means of reaching his destination except where there is a difference in the cost of transportation. An elevated line offering frequent service at 16 miles an hour will divert through passengers from the street car tracks on which a 10-mile schedule is given to a greater extent as the distance from the downtown district increases.

Table 2.—Travelling Habit in Principal Canadian Cities.

City.	Population 1915.	Total journeys per year.	Journeys per inhabitant.
Montreal	600,000	155,529,438	259
Toronto	520,000	155,255,972	300
Winnipeg	233,000	53,640,490	230
Vancouver ...	138,000	46,330,096	336
Hamilton	116,000	17,062,871	147
Edmonton	68,000	11,886,810	175

It is, however, a mistake to generalize upon such matters as passenger movement which should be made the subject of a special study in every particular case. An estimate of the tributary population being reached, it is necessary to compute the average travelling habit which denotes the number of rides per person per year and varies from 300 to 360 for urban communities. For the city of Toronto the average value over the last two years was 315 whilst for Greater New York the figure was 356. Obviously the tributary population multiplied by the travelling habit gives the total number of trips over the railway per year and at the standard five-cent fare this total divided by 20 is the gross revenue in dollars.

In estimating the total cost of the equipment for an electric railway we are mainly concerned with maxima. In other words, the number of trains, size of feeders, size and number of substations and car houses are dependent not upon the average number of persons carried throughout the day but upon the maximum carried during the peak hour. On the other hand, it is the average passengers travelling from which our receipts are calculated, and this conclusion brings in the load factor. The ratio of average to maximum people travelling is always distressingly low in the case of rapid transit railways and may in some cases be too low to render the railway a paying proposition. We have already seen that the total annual passengers can be arrived at from an estimation of the tributary population and the travelling habit. Dividing this total by 365 gives the daily total and the problem remaining is to determine just how these passengers are distributed throughout the day.

Table 3.—Total Cost of Equipment for Rapid Transit Railways.

Passengers per hour, maximum.	Trains per hour.	—Trains per mile— Single.	Double.	Cost per mile, double track. Trains.	Feeders.	Sub-stations.	Car houses.	Total.
			(A) Elevated Subway Lines.					
10,000	11.1	.70	1.40	$118,000	$ 7,000	$ 22,400	$ 14,000	$161,400
20,000	22.2	1.25	2.50	210,000	12,500	40,000	25,000	287,500
30,000	33.3	2.08	4.16	350,000	20,800	66,600	41,600	479,000
40,000	44.4	2.78	5.56	465,000	27,800	89,000	55,600	637,400
50,000	55.5	3.47	6.94	584,000	34,700	111,000	69,400	799,100
60,000	67.0	4.20	8.40	703,000	42,000	135,000	84,000	964,000
			(B) Tube Lines.					
10,000	15.5	.97	1.94	109,000	9,700	31,000	19,400	167,100
20,000	31.0	1.94	3.88	218,000	19,400	62,000	38,800	338,200
30,000	46.5	2.90	5.80	325,000	29,000	93,000	58,000	505,000
40,000	62.0	3.90	7.80	437,000	39,000	125,000	78,000	679,000
50,000	77.5	4.85	9.70	545,000	48,500	155,000	97,000	845,500
60,000	93.0	5.80	11.60	650,000	58,000	170,000	116,000	994,000

ROAD ORGANIZATION.*

By Geo. S. Henry, M.P.P.,
Secretary, Ontario Good Roads Association; Member of Toronto and York Highway Commission.

ORGANIZATION is an essential in the successful carrying out of any large undertaking, and efficient organization in road work produces results just as surely as in railroad work or commercial enterprises.

Before we outline the organization which we consider suitable for road work, we would like to interject that much as we admire good organization, we are of the opinion that men of the proper type for the work they are undertaking are more essential than organization. Good men, men who know their work, although weak in organization but anxious to build roads, will accomplish better results than inexperienced, unambitious men, no matter how thorough their organization. Our conclusion therefore is, that in the organization which we will outline, good men must fill the positions to secure any real benefit from the organization.

The selection of a chief engineer is perhaps one of the most important appointments which would have to be undertaken.

If the work is large enough, the chief engineer may be able to form separate departments with experienced men as heads of each department, but as a rule the work is not of that character and it is in this situation that the larger provincial commission can give expert service to the road builder who is not expert.

Designing Engineer.—Taking it for granted, however, that the work is large, and a designing engineer can be employed who can take charge of the office work and the design of bridges, roads, culverts, etc., it will be found that such a man will be best employed giving his full time to office work. The designs thus prepared under the direction of the chief engineer will then be turned over to the constructing engineer.

Constructing Engineer.—The constructing engineer should, under the chief engineer, have full control of all construction work, whether done by day labor or under contract. Experience has shown that a proper combination of day labor work and contracting will give the best results. The day labor gangs under the constructing engineer act as a break on excessive profits by contractors, and the contractors constructing similar works are a splendid check on excessive costs by day labor, and it is in this connection that an efficient treasurer can show up concisely the costs under both methods. The number of gangs employed will depend upon the amount of work undertaken, but it will usually be found that an experienced foreman can do efficient work with gangs of from twelve to eighteen men.

Maintenance Engineer.—The maintenance engineer should have charge of all roads and structures as soon as the construction department is relieved of them by the chief engineer. As a rule, the construction department should not be relieved from the responsibility of new work for at least six months after completion. If immediately upon completion a department is relieved of responsibility, it will be found that certain essential details will be consistently skipped.

Maintenance work is not so spectacular, nor does it appeal so effectively to the community as construction work, and it is therefore frequently overlooked, but it is nevertheless one of the most important departments of road work.

The patrol system under a maintenance engineer is without doubt the most efficient and finally the most inexpensive method that can be adopted. The length of patrol will vary with local conditions, and the expenditure per mile will depend upon construction costs and traffic carried. One of our most efficient patrol gangs handles some thirty miles of road, but they live at the intersection of two main highways, and are provided with a light motor truck, so that the extreme end of their beat is only some twenty minutes from their homes. By making the beats large and working two or three men together, it is found that the men take greater interest in the work and thereby accomplish more in a given time. One man working alone soon develops a very slow gait, and is without incentive to quicken his work. Where conditions are not suited to such a large organization, two men working in the centre of a seven-mile beat with one horse and a wagon can patrol the section, and in addition do a certain amount of construction work.

Where it is not possible to have three engineers, one for each of the departments mentioned, it will be necessary for the chief engineer to take charge of each department, having where possible a superintendent who can carefully inspect the field work, and where necessary give directions to the foremen.

Foremen.—Because road work is new in Canada, foremen suitable for rural or even interurban road work are difficult to secure.

We have a large body of men trained for work in cities where there is every convenience of tools, machinery and special equipment, but a foreman for road work such as we are interested in should be of a different type. He should not only be able to handle men and do ordinary building, but in addition should be able to make use of every natural condition that surrounds his work. A cross between the "buck beaver" of the lumber camp and the "walking boss" of the railroad gang.

Commence the work with few outfits and train your men, and the next year you will be able to double your gangs by using these trained men. If there is much concrete work, organize a special crew for this work, making sure you have one man who can build and place forms.

*Abstracted from paper read before the Fourth Canadian and International Good Roads Congress, Ottawa, April 10-14, 1917.

Coal and iron production in the United States in 1916 exceeded all previous records. Approximate figures for the year's production announced by the United States Geological Survey show total shipments of iron ore from United States mines amounting to 75,500,000 gross tons. In 1915 the shipments were 55,493,000 tons. The value of the iron ore produced in 1916 was $178,935,000, which is an increase of nearly $78,000,000 over the value of the iron ore produced in 1915. Of the total production more than 66,000,000 gross tons were shipped from mines in the Lake Superior district and about 5,300,000 from mines in the Alabama district. The total of pig-iron production was between 39,000,000 and 39,500,000 gross tons. The year recorded an enormous rise in the market price. Southern Foundry No. 2 iron at Birmingham rose from $13.13 to $22. Northern No. 2 Foundry at Chicago rose from $18 to $29. Bessemer iron at Pittsburgh rose from $19.85 to $35.95. The bituminous coal production of 1916 is estimated by C. E. Lescher, of the United States Geological Survey, as over 509,000,000 net tons, an increase of more than 65,500,000 over 1915. The production of Pennsylvania anthracite was 88,312,000 net tons, which was about 600,000 tons less than in 1915.

METHODS OF DETERMINING THE ROADMAKING QUALITIES OF DEPOSITS OF STONE AND GRAVEL.*

By L. Reinecke,
Geological Survey of Canada.

(Published by permission of the Director of the Geological Survey, Ottawa).

THE Department of Mines of Canada has been engaged in examining occurrences of stone and gravel available for road construction since the summer of 1914. The purpose of this paper is to outline the methods that have been used in arriving at the relative values of the deposits in any given area.

Up to the present, surveys have been confined to the provinces of Ontario, Quebec and New Brunswick. Prospecting for first-class stone has been undertaken along certain navigable waterways, but most of the work has consisted of mapping and determining the quality of all deposits of bedrock, glacial stone and gravel, within hauling distance of certain highway routes and in certain cases over larger areas.

Aerial surveys have been undertaken near St. John and Moncton, New Brunswick, in Two Mountains and Soulanges counties, Quebec, and in Kent, Essex and part of Carleton counties in Ontario. Belts of country adjoining 270 miles out of the 560-mile length of the Windsor-Toronto-Montreal highway and 150 miles of the 175-mile length of the Prescott-Ottawa-Montreal highway have been examined and mapped.

The usefulness of work of this kind to the road-builder is dependent in large degree on the accuracy with which the road-making value of the materials is deter-

Fig. 1.
Deposit of diabase, near the Montreal-Hull-Ottawa road.

mined, and it is in the hope of receiving suggestive criticism regarding the methods used that this outline is presented.

Three classes of road material—bedrock, boulder deposits and gravel—are encountered in this work and each has its own problems.

Bedrock.—A certain amount of general information is gathered regarding nearly all bedrock occurrences, but our main concern is to first classify the bedrock according to its road-making value, and then to study the different classes to find the causes of variation in strength and to determine the distinguishing marks of good stone. Knowing these, the fieldman is enabled to classify the many occurrences of bedrock that cannot be tested.

*Abstracted from paper read before the 4th Canadian and International Roads Congress, Ottawa, April 10-14, 1917.

The route survey along the north shore of the Ottawa River, between Hull and Montreal, will serve as an example of the information obtained regarding bedrock. In this instance areas of bedrock lying within two miles of the road were mapped and numbered. The photograph (Fig. 1) is an example of a diabase dike deposit.

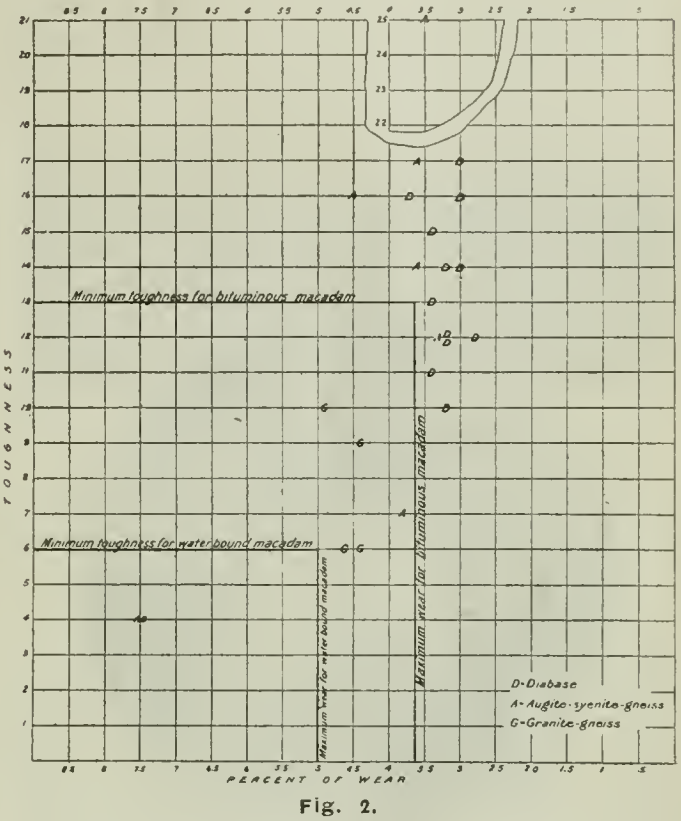


Fig. 2.
The relative percent. of wear and toughness values of the three most abundant classes of stone near the Montreal-Hull road.

The information given regarding it includes a description of its quality, the statement that about 100,000 cu. yds. of diabase can be obtained from the deposit above ground water level, that it can be economically quarried, and is about two miles from the proposed highway and a railroad.

Determination of Relative Value.—In order to discover the relative quality of the stone available in the area, the rocks were first divided into geological formations and the formations into rock types. Rocks made of the same mineral particles, under the same conditions, at about the same time, and subjected since then to the same earth stresses, are, under this system, grouped together. Certain of the groups, from the previous experience of road-builders with material of a similar kind, can be at once rejected. In this area, after rejecting certain soft, coarse, crystalline limestones, friable sandstones and much altered gneiss as unfit for road work, there remained six classes of stone. A number of samples of each of these were then tested in the laboratory and their behavior under the action of traffic studied wherever that was possible. Upon the results of the tests, modified by data regarding the uniformity of the product obtainable, and other considerations, decisions regarding the usefulness of the rock types in road surfaces were based.

Laboratory and Service Tests.—A digression may be made here to discuss the laboratory and service tests. Of the five standard tests performed in the laboratory the most important are those of per cent. of wear or abrasion, toughness, and cementing value. The standard methods

of making the tests have been fully described by Jackson.[1] They simulate the action of traffic on fragments of broken stone in a road-bed. Loads passing over a broken-stone road abrade the fragments at the surface and cause slight movement and internal abrasion between the fragments in the road mass. The blows of horses' hoofs and of swiftly moving vehicles bouncing from small obstructions on the surface test the toughness of the stone. The pressure of loads and the action of rain water cause the upper surface to cement into a solid mass, and this bond is in turn destroyed by winds on a dry road surface, and by the frictional pull and elastic rebound of rubber tires.

Laboratory tests are arbitrary but they are uniform and standard, and therefore afford a means for comparing rocks. A fair comparison between two kinds of stone under actual service conditions can scarcely be obtained unless the roads on which they are used are constructed under somewhat similar conditions and have to bear about

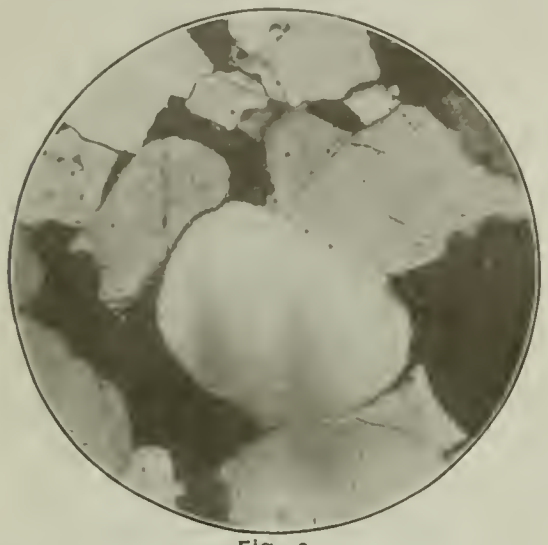


Fig. 3.

Thin section of Potsdam sandstone. Toughness 4, percent. of wear 8. Enlarged about 40 times. The large dark and white areas are mineral grains; the black lines between grains are voids in the rock.

the same kind and amount of traffic. Where road-building has just begun, such a means of comparing two types of stone are in most instances not available. The comparison of laboratory and service tests have enabled engineers to specify certain laboratory values for stone to be used under certain conditions of traffic and on certain road surfaces. Thus the lowest allowable toughness for stone in the surface of waterbound macadam is placed at 6, the highest allowable per cent. of wear at 5.[2] For moderately heavy traffic the stone should have a toughness of from 10 to 18 and for traffic of 250 vehicles per day and over, over 18.[3] For bituminous macadam, which is generally used only when the traffic is fairly heavy, a minimum toughness of 13 and a maximum wear of 3.7 is called for.[4]

[1]Jackson, Frank H., Jr., "Methods for the Determination of the Physical Properties of Road Building Rock," U.S. Dept. of Agric., Bull. 347, Washington, D.C., 1916.

[2]"Progress report of the special committee on materials for road construction and on standards for their test and use." Amer. Soc. Civil Engineers, Proceedings of the Annual Meeting, June, 1917, p. 1621.

[3]Hubbard, Prevost and Jackson, F. H., Jr. "Relation between properties of hardness and toughness of road-building rock." Journ. Agric. Research, Washington, D.C., Feb., 1916, p. 906.

[4]"Specifications for broken stone and gravel roads," adopted Oct., 1914, by Amer. Soc. of Municipal Improvements, Indianapolis, Ind., p. 7

In Fig. 2 the results of tests for toughness and wear upon three of the better classes of stone that are found near the Montreal-Hull Road are shown graphically. The limiting toughness and per cent. of wear of stone suitable for waterbound and bituminous macadam are indicated by

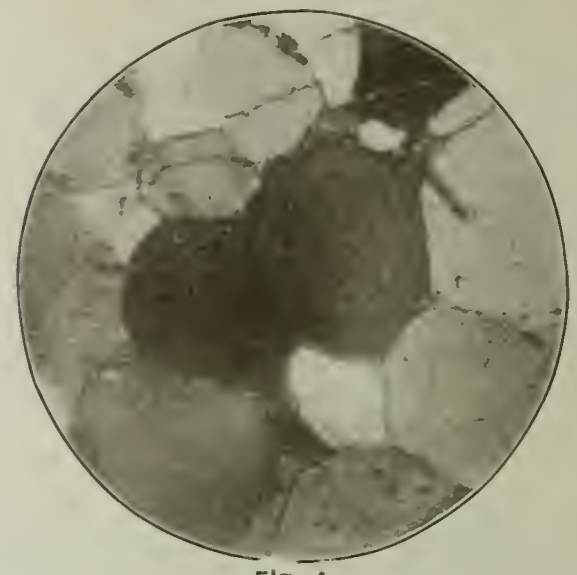


Fig. 4.

Calcareous sandstone of the Beekmantown formation, toughness 8, percent. of wear 3.6. Enlarged 50 times. The original round sand grains have become angular by crystalline growth of silica in the void spaces, all other voids filled with a lime cement.

heavy lines in the figure. It is evident that the strength of the samples of augite syenite gneiss and of the diabase are about equivalent and that both give much better results than granite gneiss. In judging of the relative values of the three classes, however, diabase is placed before augite syenite gneiss, because the stone in a deposit of diabase is more uniform in quality than the gneiss. On the other hand, when granite gneiss is the only stone available, for a certain stretch of road, the more massive and less altered portion of the deposit is recommended.

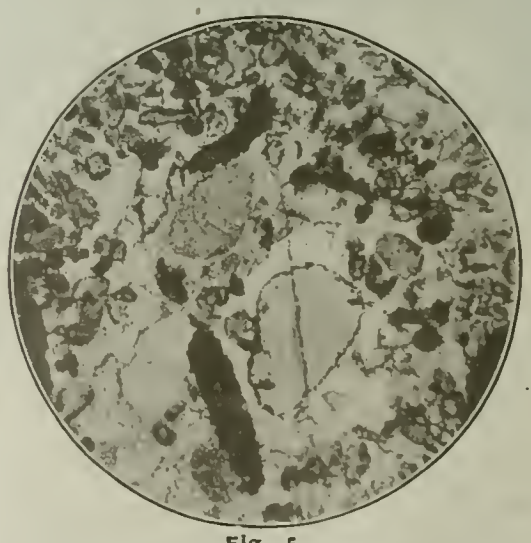


Fig. 5.

Trenton limestone enlarged about 20 times. Percent. of wear 4.7, toughness 4. Note the dark and light grains of calcite and the long cracks along cleavage planes.

When it is possible to separate geological formations into areas, as in the case of part of the Ottawa-Prescott survey, the outcrops within whole areas may in many cases be at once rejected. The formations in this neighborhood consist of bedded sediments, dolomites, lime-

stones, shales and sandstones, and the stone worth considering occurs in four formations. A number of samples were tested from each, and compared in the manner indicated above for the Hull-Montreal route. It was found that certain dolomites and calcareous sandstones of the Beekmantown formation gave uniformly better results than the others. They were, therefore, recommended as the best available local material. Service tests substantiate this conclusion. Where dolomite is used on the roads near Ottawa it has stood up well in certain instances under traffic up to about 200 vehicles per day. The limestones of the Chazy, Black River and Trenton formations, on the other hand, which are commonly used near and in Ottawa, usually wear to dust, and holes rapidly under similar conditions of traffic.

Causes of Differences in Value.—The method of laboratory tests has the disadvantage that usually only one out of five or ten of the deposits examined in the field can be tested, and the sample tested is only a small portion of a large deposit. More frequent and close sampling is not often practicable, and the results of the tests are, moreover, in many cases not available until after the field work is done. For efficient work, therefore, it is necessary for the field man to know the distinguishing marks of a good road stone, and the best way to arrive at them is to discover the causes of the difference in strength and cementing value of stone. For this purpose both the microscope and chemical analyses are used. Careful and extensive comparison of the microscopic texture with the results of laboratory tests upon road stones have been carried on at the Office of Public Roads at Washington.[1] The results of this work have furnished a basis for classifying the main rock classes in regard to their road-building qualities. But just as men of the same race and age differ greatly in their powers of endurance and their capacities for absorbing food, for instance, so do rocks of the same class vary in strength and cementing value. The characteristics of the rocks in each particular field must, therefore, be studied in order to do effective work.

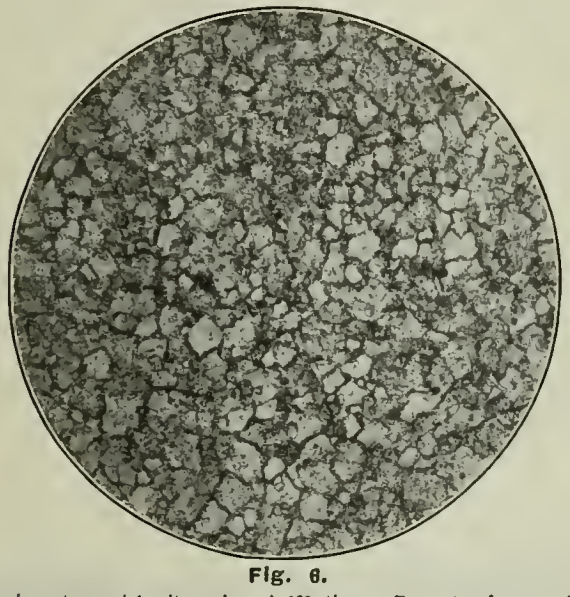


Fig. 6.

Beekmantown dolomite enlarged 100 times. Percent. of wear, 4.4, toughness 13. The dirty grains of dolomite are of about the same size and closely packed together.

In the two thin rock sections shown in Figs. 3 and 4, the cause of the greater strength of the calcareous sandstone associated with the Beekmantown dolomite over that of the sandstone without lime-cement is apparently caused by secondary crystalline or angular outline, and to the calcareous cement which fills all voids in the rock, even cracks of 3/10,000 of an inch wide, as shown in Fig. 4. This lime-cement, which is the principal cause of the difference in strength, can be recognized in the outcrop and is therefore a help to the field man in selecting the better rock in the field.

Fig. 7.

Boulder fences near Kemptville, Ont. They consist of about 95 percent. hard and 5 percent. soft boulders.

A comparison of the thin sections of Beekmantown dolomite with Trenton limestone (Figs. 5 and 6) shows that the dolomite consists of dark grains of even size packed closely together, the limestones consist of dark, irregular grains loosely held together by pure white grains. All of the grains in these specimens are made up of the minerals dolomite or calcite which cleave easily in three directions. In the uneven coarse-grained rocks the cleavages in the large white grains form relatively large planes of weakness—a fitting starting place for cracks in the rock. In the fine, even-grained dolomite the short cleavage in one grain is usually in a different plane from that in the adjacent grain and an incipient crack starts with a rough surface and does not develop as easily. It is inferred, also, that impurities such as those in the dark grains tend to prevent slipping along the cleavage planes and so strengthen the rock. Chemical analysis and the weathering of the stone proves that the impurity in dolomite is extremely fine silica, in the form of silt. In

Fig. 8.

A boulder fence near Spencerville, Ont. It carries 90 percent. of limestone.

[1] Lord, E. C. E., "Relation of mineral composition and rock structure to the physical properties of road materials," U.S. Dept. Agric. Bulletin 348, 26 pp., 1916.

this region, then, fine, compact, even-grained dolomites that weather to silt can be considered by the field man of better road-making quality than limestone of irregular texture.

In the case of the gneisses referred to before as occurring along the Hull-Montreal route, microscopic work revealed that the mineral augite was almost invariably present in the more durable gneisses. In this area, therefore, augite could be used to identify the better classes of gneissic rocks. These instances are cited to indicate the line along which work upon the strength of the stone will proceed in the future. Chemical work to determine the

Fig. 9.
A good concrete gravel near Kemptville, Ont. Pebbles 95 per cent., limestone 5 soft; impurities in very small amount.

causes for the variation in cementing value has been begun but has not so far yielded results of value.

Boulder Deposits or Fieldstone.—Fieldstone or glacial boulders are found piled in fences and heaps in cleared farming country and form an important source of road material.

The composition of the boulder aggregates is an average of estimates of composition made for practically every fence, the yardage is measured fence by fence and compiled for the area.

Here, again, the problem is to distinguish between boulder aggregates that will make good road surfaces and those that will not. The aggregates are, except in rare instances, made up of a number of rocks varying in character, Figs. 7 and 8. They have in this area been grouped into hard, limestone, and soft, the hard being made up of rock classes considered of good, the limestone of intermediate and the soft stone of poor wearing quality. The presumption is that the durability of the stone in a road surface depends on the relative amounts of these three classes present in the aggregate.

Experiments are being carried on in the laboratory of the Department of Mines to determine the per cent. of wear of aggregates consisting of various proportions of durable, intermediate and soft rocks. The idea is to find standards by which the durability of a boulder aggregate may be judged of in the field. It is necessary for the field man to have some idea of the relative durability of the bedrock from which these boulders come, before he can use this classification to advantage in the field. Because of the many miles of road that will have to be built of crushed fieldstone in Canada, we believe that results along this line will be of value.

Gravel.—Gravel is the last and perhaps the most difficult of the deposits with which we have to deal. Gravel areas are mapped in the field and numbered in the same way as the bedrock and fieldstone areas, the numbers differing in color for each of the three kinds. Information regarding the gravels is compiled in two tables, one describing the character of the gravel, the other giving information regarding its exploitation and uses. In the table dealing with the character of the deposits, depth of weathering, texture or grading of sizes, impurities and pebble composition are given. The relative amounts of boulders, gravel and sand as given are correct only for the pits examined. Gravel deposits vary so much throughout their extent that an average of the texture cannot be obtained except by sinking test pits or auger holes. Except in the case of the silt content, no field method has been devised as yet for estimating the percentage of impurities present. There is a great need here for laboratory and field work, because of the importance of the influence of the impurities and fine silt content upon the strength of concrete and in sheet asphalt work.

The gravels are tested in the laboratory for abrasion and cementing value and a mechanical analysis is made to determine the proportions of the different sizes present below three inches. An attempt has been made to trace a relationship between pebble composition and laboratory tests upon wear. A broad relation was established between the percentage of soft pebbles in the gravel and the percentage of wear, but it is by no means a close one, and since the work was done we have changed our system of pebble classification in the endeavor to evolve some scheme whereby an estimate of pebble composition would enable the field man to predict more closely the durability of the gravel he was examining. It should be stated that the present standard methods for making the abrasion test for gravel are not wholly satisfactory, and the wear of the gravels on roads has in certain instances confirmed the conclusions drawn from their pebble composition rather than from the results of laboratory tests. Figs. 9 and 10 illustrate a good concrete gravel and a poor gravel deposit near the Ottawa-Prescott Road.

As this outline indicates, many of the methods used for determining the value of road materials are far from satisfactory and we believe that improvements may be effected both by close co-operation both with those engaged in road building and with men who are testing stone and gravel in other laboratories.

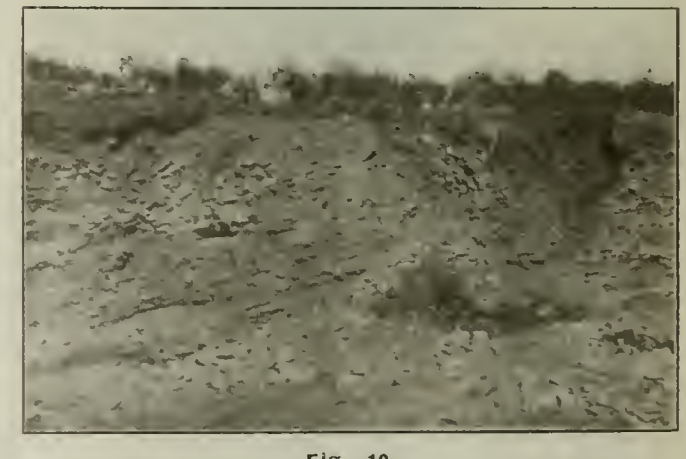


Fig. 10.
A poor gravel near Ottawa. 20 to 40 percent. of the pebbles are of soft stone, and an appreciable amount of clay, iron oxide and lime carbonate is present.

The writer very gratefully acknowledges the courtesy and help he has received from road engineers and especially from the Ontario Highway Department. He is no less indebted to the men in charge of the testing laboratories of the Office of Public Roads in Washington and

at Columbia University, with whom our laboratory is now co-operating in work looking toward the general improvement of the laboratory tests upon road stone and gravel.

Summary.—In order to determine the road-making values of the rocks in a certain district they are first divided into formations and then into rock types. Their average values and the variation in strength and cementing value of each type is obtained by laboratory tests on a number of samples and the results thus obtained are compared with actual service tests in the roads wherever possible. Laboratory studies with the microscope and by chemical analyses are then undertaken to discover the cause of such variations in order to furnish data which will enable the field man to distinguish a good stone from a poor one in the outcrop. With a working knowledge of the strength of the bedrock in a district, an attempt is made to devise a classification of the kinds of boulders in the fieldstone deposits in such a way that their composition expressed in percentages of durable, intermediate and soft boulders will bear a direct relation to their percentage of wear as determined in the laboratory, and to their durability under traffic conditions. The pebbles in the gravels of the district are classified in a manner that will bring about the same result. The impurities present and the texture or grading of the gravels are studied in order to furnish advanced data as to their probable value in concrete and sheet asphalt work.

AMERICAN WATERWORKS ASSOCIATION.

The 37th annual convention of the American Waterworks Association will be held May 7-11, 1917, at Richmond, Va.

Monday, May 7th, will be devoted to meeting of the executive committee, registration, and the delivery of the president's address.

Tuesday.—Forenoon session: Regular order of business; announcement of officers elected for 1917-1918. Reading papers. "Recent Tendencies and Progress in Waterworks Practice," John W. Alvord; "The Use of Concrete in Waterworks Structures, With Special Reference to Its Resistance to Elemental Action," R. J. Wig, U.S. Bureau of Standards. Discussion by J. Waldo Smith, Allen Hazen and others. "Water Supply for Military Camps," John D. Kilpatrick; "Enforcement of Standards for Water for Interstate Carriers," H. P. Letton.

Afternoon session: Reading papers. "Reliability in Pumping Station Design," Clarence Goldsmith; "Improved Efficiency of the St. Louis Pumping Stations," Leonard A. Day; "Pumping Station Efficiency in Boston," O. A. Doane; "Pumping Station Costs and Efficiency Records," Mark Wolff. Discussions by Carleton E. Davis, Theodore A. Leison, and others. "Relations Between Water Departments, Companies and the Public," W. C. Hawley; "Relations Between a Water Department and the Public," A. A. Reimer.

Evening session: Reception in auditorium of The Jefferson (the room in which the meetings are held). Music, dancing and refreshments, provided by Waterworks Manufacturers' Association.

Wednesday.—Forenoon session: Reading papers. "Some Problems in Filtration Plant Operation," Louis I. Birdsall; "Decarbonation and Removal of Iron and Manganese from Ground Water at Lawrence, Massachusetts," Frank A. Barbour; "A New Form of Screen Chamber" (illustrated by lantern slides), John H. Lance.

Evening session: Reading papers. "History of Cast Iron Pipe Prices," Burt B. Hodgman; "Experience with Submerged Pipe Line in Water Supply of Puerto Barricas, Guatemala," T. Howard Barnes; "Troubles in Constructing a 48-inch Submerged Main," F. W. Cappelen; "The Effect of Covering a Service Reservoir," John Gaub.

Thursday.—Forenoon session: Reading papers; topical discussions. "Thawing Frozen Water Mains by Electricity," Henry B. Machen. Discussion by William I. McMane, Harry M. Beardsley, and others. "Trench Machine Work," William W. Brush. Discussion by I. M. Higbee, George G. Earl, Beekman C. Little, John C. Tiernt, of Oradale, N.J., N. J. Whealem, Elizabethtown, N.J., Leonard Metcalf (data from Indianapolis, Denver and Los Angeles), and others. Experience papers. "Unusual Experience in Laying 24-inch Pipe," D. W. French; "Leakage from Joints of Vitrified Pipe Used to Convey Water Under a Low Head," William W. Brush; "Leaks from High Pressure Fire Service Mains," Henry B. Machen. Discussion by Carleton E. Davis, and others.

Afternoon session: Experience papers. "Forty-five Years' Experience in Waterworks," E. E. Davis; "The Formation of a Bonding Company to Promote Water Sales and Sanitation," F. C. Jordan; "Lead Wool and Its Advantages," Robert J. Thomas; "Methods of Determining and Plotting Meter Capacities," Fred B. Nelson; "Lowering Ground Water Levels," Clarence L. Kirk; "Results of Experiences and Experiments with Wrought Iron and Steel Service Pipes," Alex. Milne. Question box and topical discussions. List of questions and topics in separate program.

Evening session: Reports of officers and standing committees, as follow: Executive committee, secretary, publication committee, treasurer, finance committee, membership committee, nominating committee. Reports of the following special committees: Electrolysis, Albert F. Ganz, chairman; representatives upon National Electrolysis Committee, D. D Jackson, chairman; Standard Specifications for Hydrants and Valves, Beekman C. Little, chairman; Constitution, Morris R. Sherrerd, chairman.

Thursday.—Chemical and Bacteriological Section. Forenoon session: Reading papers. "Standards of Water Supply," W. J. Orchard; "Determination of B. Coli," William Mansfield Clark, U.S. Bureau of Animal Industry; "Quality of Water and Tests for B. Coli," Abel Wolman, Maryland State Board of Health.

Afternoon session: Reading papers. "Manganese in Water Supplies," Edward Bartow and H. P. Corson; "New Electric Chlorine Plant of the Montreal Water and Power Company," F. H. Pitcher and James O. Meadows; "Chloramine Treatment at Ottawa, Canada," Joseph Race.

Friday.—Forenoon session: Reports of the following special committees: Private Fire Protection Services, Nicholas S. Hill, chairman; Depreciation, John W. Alvord, chairman; Revision of Standard Specifications for Cast Iron Pipe, John H. Gregory, chairman; Revision of Standard Specifications for Wrought Iron Pipe, A. A. Reimer, chairman; Water Consumption, Edward S. Cole, chairman; Prevention of Stream and Lake Pollution, Theodore A. Leisen, chairman; Mechanical Analysis of Sand, Philip Burgess, chairman; City Planning, Ernest P. Goodrich, chairman; Classification of Technical Literature, Nicholas S. Hill, Jr., chairman. Topical and general talks for the good of the association.

Afternoon: Entertainment by the city of Richmond. A special train will leave the Main Street Station promptly at one o'clock, for the Richmond settling basins; thence to the Richmond pumping station, where luncheon will be served, followed by dancing and picnic features. Return to city by trolley at the convenience of the members.

CANADA'S RAILROAD PROBLEM

ANALYSIS OF THE ADVANTAGES OF GOVERNMENT OWNERSHIP—RAIL AND WATER FACILITIES—ELIMINATION OF THE WASTES OF COMPETITION

By W. T. JACKMAN, M.A.,
Department of Political Science, University of Toronto.

THE present juncture in our national development, when great questions are pressing upon us for appropriate solution, brings before the public, among other vital issues, the problem as to what is to be done regarding the railways of the country. Probably there is no other phase of our economic life which is of greater importance to all classes of the people. The value of the transportation services brings before each of us, whether engaged directly in business or indirectly affected by business interests, the intimate relation which so clearly exists between the welfare of the railways and that of the general public, that I venture to advance some considerations which may help to set this far-reaching transportation problem in its proper light. But, before proceeding further, may I say that I am not writing with any partisan purpose in view, nor am I endeavoring to put forth a panacea for the relief of all the railway ills of the country; my aim is to impartially consider some aspects of this great question which need to be kept perpetually before us, especially in view of the many advocates who are urging a complete change in our policy of dealing with these vast interests. We should not seek any such change without serious study as to the probabilities of the outcome. May I reiterate that in treating this subject I am anxious to be just to all classes, both to those who are in favor of and those opposed to government ownership of the railways. Only by seeing the problem from all sides can we weigh the relative merits of government and private ownership so as to come to a judicious conclusion. Leaving aside any bias, therefore, let us look at the problem with judicial mind.

The importance of the railways to the country and the difficulties encountered by them in the financing of their operations have been so great as to cause the government last year to appoint a railway board of inquiry composed of experts, to go into the situation thoroughly and report its findings and recommendations. This board has recently completed its labors and from the statements published in advance of the report itself, it seems as if a majority of that body were in favor of the nationalization of the Canadian Northern and Grand Trunk systems. Of these two, the Canadian Northern has been unable to meet a large portion of its fixed charges, and the Grand Trunk Pacific, a subsidiary of the Grand Trunk Railway Company, while unable to meet any of its fixed charges, has also had a large deficit in its operating expenses. These facts have compelled the two companies to appear before parliament and ask that body to advance them the necessary assistance to enable them to discharge their financial obligations. From all appearances, these companies, if left under present control, may have to seek such aid for several years, for both of them have been expending largely on capital account in the construction of new lines through undeveloped territory in the West, and it is inevitable that, until the traffic of this western country is increased to such an extent as will permit the roads to pay their own way, assistance must be obtained from other sources than the traffic. Because of the necessity of obtaining relief from governmental sources, the railways, it is said, should be taken over by the government; and one of our leading dailies closes an editorial on "Canada's Railway Problem" with the sentence: "The next grant of public money for railways must carry public ownership with it." Taking the utterances of the press in connection with the foregoing recommendation of the board of inquiry, it is manifest that there is a strong sentiment in favor of this proposed change.

It is not our purpose here to endeavor to settle this vexing problem. It has too many ramifications to be treated lightly or to be summarily disposed of by a few glib statements as to the evils of private ownership and the advantages of government ownership. Nor can we settle it by pointing to a few instances of private railways whose managements have been corrupt and have flagrantly broken faith with the public, much less by taking certain examples of government ownership which have been successful and holding these up as models upon which to pattern our system of administration. It will be much to the advantage of this country if the Ottawa government refuses to act hastily in this matter. In such a momentous issue, nothing is gained by precipitate action and nothing really advantageous is lost by taking time to consider all sides of the case. We think it would be unwise to use the present exceptional circumstances—a time of tremendous stress on account of the war and the dislocation of industry, a time of intense mental unrest—as the occasion for changing a system of transportation which has grown up gradually during the past sixty years, responding to the country's needs, showing wonderful adaptability and displaying initiative and ability of a high order. Such a system of administration, under which the extension of the transportation facilities has been of untold service in the development of agriculture, trade and manufactures, and which has been to a large extent responsible for the great prosperity and increasing wealth of this country, should not be cast aside unless there is at hand a new and better system which would indubitably carry on this service with equal or greater results. Let us, then, consider briefly, but carefully and deliberately, the proposed change and weigh the arguments pro and con with unbiased judgment.

First of all, what are the arguments in favor of government ownership in Canada?

The necessity on the part of the Dominion government to meet the guarantees of bond interest for the Canadian Northern and Grand Trunk Pacific railways without having any immediate control of these roads would seem to be contrary to any sound business policy. Any private corporation which has assumed the payment of interest on its bonds must be given full control of the property; and ostensibly the same prerogative would be expected in the case of a public corporation like the government which wished to conduct its affairs on strict business principles. The assumption of responsibility is correlative with the exercise of rights. But, in the case of these two roads, it would seem that the government has undertaken to guarantee and pay the interest on the bonds without having the privilege of controlling the financial operations of the companies. How long would any private enterprise endure which continued year after year to pay sums of

money for expenditures over which it had no control? Bankruptcy would soon issue from such a course. The only reason it is not so with the government is that the latter makes its revenue large enough by taxation to meet its expenditure, while in the case of a private concern the course is just the opposite—its expenditure must be kept within its revenue. But although the government is in this respect fundamentally different from a private enterprise the same business principles which are recognized as judicious in the latter are the only principles upon which the former should act. To go contrary to these would be to court loss of confidence on the part of those who endeavor to exercise judgment and discretion in human affairs.

By government ownership of the railways it is hoped that both rail and water facilities would form one harmonious unity, operated for the public welfare. There are certain kinds of transportation which can only be done, or can be done most efficiently, by railway; and there are other kinds of traffic for which water transportation would seem to be more suitable. With the great system of inland waterways we have potential facilities which our government is wisely developing. Immense sums have already been spent in improving these waterways and the harbors upon them and yet, because the railways and waterways are not co-ordinated into a unified system much of the benefit from the navigation on the Great Lakes has not been conserved. Whenever definite steps have been taken by the government to enlarge or improve the canals and to preserve and extend navigation facilities of all kinds, the railways have consistently opposed anything which seemed likely to divert traffic to the water. Large interests have been secured by them in the water fronts of the important shipping centres, and for their own advantage they have been diligent in preserving these lands best adapted to navigation uses. Naturally, it has never been the policy of the railway companies to welcome their rivals. They have invariably sought to restrain such rivalry. But under government control and ownership these conflicting interests could be harmonized so that each would fulfil its own particular function with the greatest economy and acceptability to the public. And why should not the public receive the greatest advantage from the transportation facilities which are maintained by the contributions of the public?

Another important factor supporting the contention in favor of government ownership is that thereby the wastes of competition would be eliminated. It was long held that competition was the life of trade and that every business was naturally competitive. But we have outlived that day and can see that certain kinds of enterprise are naturally more monopolistic than competitive. Legislative bodies in Canada, as well as elsewhere, have, however, not abandoned the view that prevailed in the early railway era that the public interests can be most effectively guarded by authorizing the construction of two or more lines along the same general route. To have two or three separate and competing railway companies, each with its own complement of necessary facilities, and the multiplication of lines, stations, offices and officials with the vast expense connected with their maintenance, is to conduct the business in the most uneconomical method possible. The railway companies themselves early recognized this wasteful policy and endeavored to get together into working agreements; but legislatures, ignorant of the real nature of the railway business, have, under the strong pressure of railway interests, sanctioned the construction of new lines where the existence of the latter has been a sheer waste of public funds, thinking thereby that they were upholding competition in furtherance of the public welfare.

How great has been this duplication or triplication of lines in Canada a casual inspection of our railway system will reveal. The fact that railway magnates themselves have been the aggressors in this movement does not alter the fact that legislatures should have resisted appeals of this kind. Nor can we say that such appeals have yet ceased; on the contrary, the financial forces are even now arrayed to secure similar additional concessions for the building of unnecessary lines of railway, while other portions of the country are in great need of the facilities of transportation. Under a system of government ownership this great waste of capital could be avoided if we had those in the government who were invariably willing to exercise as much economy in the management of the country's affairs as a business man shows in the conduct of his own private business.

Another motive leading to government ownership is that by this means equality of treatment would be given to all persons and all localities; in other words, that there would be no longer any personal or local discrimination. The reason for it would have disappeared, since government is intended to look after the welfare of all alike. It must be acknowledged that our railways have in the past been the means of building up large shippers to the detriment of the small shippers; and before the formation of our board of railway commissioners it is unquestionable that preferential treatment was given to favored persons and localities. Even at the present time, one has but to examine the decisions and judgments of this board to see the volume of complaints of this kind which come before it for adjudication.

If all the work of this arm of the government could be avoided and equitable conditions and rates be furnished to all communities and individuals without fear or favor, a long step would have been taken in the promotion of sound business morality. In most instances, the existing inequalities have been due to the fact that powerful interests recognized the fact that by their strong representations to the railway companies the latter would frequently accede to their wishes; but if the railways were owned and operated by a government whose members could resist all pleas of private interests there would be no more occasion for this kind of favoritism. Under this system there would surely be the much desired equality of opportunity for all.

Government ownership would be desirable also from the financial standpoint; at least this is claimed by those who advocate this method of administration. Under ordinary conditions, the credit of the government is so good that it can borrow all the funds it needs at 4 or 4½ per cent., perhaps less; while private companies have to pay 5 to 6 per cent. for their capital requirements. In the financing of a great enterprise this saving would amount to a large sum in the aggregate; so that the amount of the fixed charges to be paid would be considerably lower. Again, since the government would operate the road at cost, no dividends would have to be paid. The savings effected from these two sources alone would be very great; consequently, under government management the revenues would not need to be so great and the result would be seen in either lower rates or increased service to the public. This assumes, of course, that public management will be as economical, efficient and productive as private management.

An argument, which is being worked to the fullest extent under existing war conditions, is that for purposes

of national defence the government should own the railways. In order to make these facilities for transportation most effective for the carriage of troops, subsistence, munitions and the raw materials for the manufacture of munitions the carriage of all other commodities, even though they pay higher rates of conveyance, must be relegated to a place of secondary importance. But when the railways are left in private hands the tendency is to take first that traffic which will pay the higher rates. Moreover, when, as in the case of the Canadian Pacific Railway, a large block of shares is owned by German or other foreign stockholders, there is great danger that the foreign influence may be so strong as to dictate the policy of the road, and thus the efforts toward using the railway for national purposes may be rendered nugatory or partially unavailing. The example of the state-owned and operated railways of Germany in aiding the mobilization of soldiers and supplies along the various fronts, and the example of England in assuming control of her railways during this emergency, have given additional emphasis to the need of having the railways completely devoted to the promotion of the national, as opposed to the private, interests.

Finally, it has been said that roads like the Grand Trunk Pacific and National Transcontinental have been intended to further primarily the interests of colonization in the great West. Settlers will no longer go, as in early years, where there are no transportation facilities. Railways must be put through in advance of or synchronously with settlement and as this project of settlement of men upon the land is for the national development, the railways designed to advance this project should also be national. Private capital does not like to invest in an enterprise of this nature in which years must elapse before the road obtains sufficient traffic to pay the operating charges, to say nothing about profits. This is exactly the condition confronting the roads above mentioned. The National Transcontinental is owned and is being operated by the government, and the chairman of the board of directors of the Grand Trunk Railway Company has requested the government to take over the Grand Trunk Pacific. It is known that the National Transcontinental line passes through a stretch of country which is as yet in its infancy so far as the capacity of furnishing traffic is concerned; the settlements along the route are widely scattered and years may elapse before a sufficient amount of tonnage can be provided to make the railway pay.

Much the same may be said of the Grand Trunk Pacific; a long stretch of the road is put through undeveloped territory and as there are no lateral lines to act as great feeders for the main line it may be a few years before adequate traffic can be obtained to pay reasonable returns on the capital invested. It is in connection with such enterprises, therefore, that public aid and support can be reasonably invoked. If private capital is averse to adventuring itself in this kind of investment without having the backing of the government to assure the financial soundness of the business, it would seem as if the government might appropriately take complete control of this enterprise without reference to private capital at all.

The government, being a permanent institution, can afford to wait for a long time before receiving financial returns from such a venture; in time, with the growth of the traffic of a developing territory, the roads which at first were unremunerative would be found to yield ample revenues, and then the government could be rewarded for the great advances made by it in the earlier years. But this contrasts strongly with the conditions attending the investment of private capital, which, if it do not receive immediate and ample returns, will prefer to seek more profitable forms of investment.

[NOTE:—The above article is the first of a series of three. In his second article, Mr. Jackman will discuss the disadvantages of government ownership of Canadian railroads. In the third article he will review suggested remedies for existing difficulties. This series will be of particular interest to those who read W. F. Tye's suggested remedy, published in *The Canadian Engineer* for February 1st, 8th and 15th, 1917, and Sir Thomas Tait's article in the April 12th, 1917, issue of *The Canadian Engineer*. Engineers will naturally place more credence in the theories advanced by Messrs. Tye and Tait, who are experienced railroad engineers and thoroughly familiar with conditions in Canada, but the opinions of Mr. Jackman, expressed from the economic viewpoint alone, will no doubt be of interest and value to those who have followed the whole discussion.—EDITOR.]

"HYDRO" STRUCTURAL MATERIALS LABORATORY.

A structural materials department has been organized in the laboratory of the Hydro-Electric Power Commission of Ontario. The laboratory building is on Strachan Avenue, where the whole testing work of the Commission is centralized. In the structural materials department are conducted all non-electrical tests. The equipment at present includes apparatus for testing cement and for making some tests on concrete aggregates and mortars. There is under consideration, however, the installation of a compression testing machine of 200,000 pounds capacity and a Universal machine of 50,000 pounds capacity. These will enable the laboratory to make tensile, compression and bending tests over a wide range.

The tests on cement include all the physical tests required by the standard specifications for Portland cement adopted by the American and Canadian Societies of Civil Engineers, and by the American Society for Testing Materials. The equipment includes a complete set of Tyler sieves from ¼ mesh to 200 mesh, also a 100 and 200-mesh sieve specially calibrated by the Bureau of Standards for making check tests on fineness, a Vicat and a Gilmore apparatus for determining time setting, specific gravity flask, tensile testing machine, a set of briquette moulds and storage basins, balance, a moist closet, etc. Equipment is also available for making some of the standard tests on sand and aggregates, but this is not yet complete.

Considerable experimental work is being done in connection with tests and test equipment for the concrete work on the proposed generating station at Niagara. This is to determine a standard method of procedure in the testing of sand, mortars and aggregates. The importance of testing work of this nature is now universally recognized.

Other test work done by this laboratory includes galvanizing tests on line construction material received in the storehouse, tests on paints, varnishes, wood preservatives, etc. This work is expanding as the needs of the Commission enlarge and will be an important part of the testing service rendered by the laboratories.

Work has been commenced upon the construction of a storage reservoir of ample dimensions for furnishing the city of Pachuca, Mexico, and its neighbouring villages with an ample supply of pure water—something that is greatly needed.

REPAIRING GRAVEL AND STONE ROADS.*

By R. M. Smith, B.Sc.,
Assistant Engineer, Dept. of Public Highways, Ontario.

WE have all classes of roads and as many as they are they all need repair. The concrete, the asphalt, the brick, the wood block, have become fairly well standardized in their method, most municipalities operating along same lines. Why, we ask, cannot the repairing of stone and gravel roads become just as consistent? Is it because of the ever-changing conditions or is it a simple case of neglect on our part? Two years ago an article read at the first conference discussed at some length a method of caulking horses' shoes that the road might not be torn up. At the present time we have almost forgotten the horse-drawn vehicle and on every hand you hear the words "automobile traffic." The cities have constructed roads to meet this traffic, but the cost of these would be prohibitive in the country, so what is the next best thing?

Many miles of macadam and gravel roads have been constructed throughout the province and now that they are constructed, how shall we keep them in repair under this above-mentioned automobile traffic conditions?

There are two things which should be remembered: First, roads deteriorate rapidly if neglected,—frost, heat, water, drought and traffic tending to flatten the surface and mix it up so badly that it is pounded into the sub-grade; second, the macadam or gravel road constructed at present time will not stand up under the increasing traffic without attention.

Construction or resurfacing a macadam or gravel road must never be undertaken until ditches are provided and culverts have the proper outlet. To get the water away from the road should be the first consideration; too often this, the most important item in resurfacing or construction, is neglected. The idea seems to be to place the stone on the road as fast as possible, round it into shape regardless of mud holes, soft spots and drainage, letting the water take care of itself. It is not the intention of this paper to go into the method of construction, or drainage, however, but certainly the method of construction has all to do with the method and cost of repair. Often we see gravel being dumped into a mud hole on a clay road or a soft spot in a gravel road being filled with something else. Sometimes we see bituminous patches on a macadam road which apparently have no oil elsewhere. Mixing materials in this way either causes bumps or hollows. Repair a clay road with clay; a broken-stone with stone and a gravel with gravel.

Macadam Roads.—Repairing a macadam road should be started as soon as the road is constructed. It is practically impossible to construct a water-bound macadam that under the traffic of to-day will not rut. Automobiles are like sheep,—if one starts a rut the next one follows. The first rain fills the rut with water and the trouble has started. "Allow no ruts to form" should be the motto of road superintendents; keep the surface round and smooth. This enables the water to get more quickly to the ditch and eliminates bumps and holes that would form otherwise. Broken stone, the same size as used in the upper course, should be used for filling ruts; it must be tamped to place, the finished surface a trifle higher than the surrounding surface, to allow for consolidation by traffic. Pot holes are repaired in Europe by the removal of material to depth of wearing course, stone then replaced, tamped to grade with stone chips as top dressing. Bituminous material may be added, either before or after placing. Rolling in spring when road is soft has also brought good results. The earth shoulders should be trimmed up from time to time with road scraper that water may run freely to the ditch. Continuous repair is the only way to increase the life of the road. Too often roads are constructed and are left to themselves from two to three years—sometimes a considerable time longer—without the slightest attention. We must convince ourselves that repairs are essential and immediately the road is completed, not a year or so later. The greatest care that we can exercise during construction will not entirely remove all the soft spots and these soon start to put in their appearance. A few loads of material dumped conveniently along the road at the time of construction will be handy to fix just such a place. The next question that arises is: Who is to make the repairs? We must provide systematic method of repair and maintenance. Too little attention has been given to this end of the work. How often we drive on the country road directly after it has been constructed and see signs of ravelling and rutting that with a few minutes' attention could be made as solid as surrounding surface.

Combination of Hand Plow and Roller.

The continuous patrol system that has been advocated by engineers both in Canada and the United States has either not found favor in Ontario or else we have neglected to carry the idea far enough. The railroads have their sectionmen who keep the track and surface in repair, why cannot the same system be applied to our public roads? Until such a system is inaugurated we will have the same high cost of resurfacing every few years. To save money to our councils and province it is essential that we realize immediately the importance of systematic maintenance and take steps to remedy the evil that has existed since road construction in Ontario began. When our shed starts to leak, we patch it; when our road surface is penetrated why not give it the same attention? Only one case exists, to the writer's mind, where patrol systems with continuous maintenance might not be to advantage, and that is where road is constructed of a soft material that is plentiful and easily obtained.

The time must come, however, when patch work and the best system of patrol will not suffice to keep the surface in shape; then it must be resurfaced. Where the road is full of pot holes the scarifier or picks bolted to rear wheels of roller can be used to advantage. The

*Abstracted from paper read before the Third Annual Conference on Road Construction. Held in Toronto, March 27-30, 1917.

scarifier brings the stone to surface, making a better bond for the new material when placed upon the road. The surface is then watered and consolidated with the roller. Where in the original construction the stone was of a considerable depth this method of resurfacing may be sufficient for a year or so. However, if in the original construction the surface was thin, new material must be added. It is advocated by many engineers that where more than three inches of material is being placed on the old surface it should not be disturbed, but new material applied, watered and rolled just as in new construction. On a considerable mileage of our country roads we have gone a step further than this and added a bituminous material in our resurfacing. This has several important advantages,—it makes a surface that is impervious to water, has better wearing qualities, is dustless, and eliminates the high crown we dread so much in new construction, ½ inch to the foot being considered quite sufficient to carry water to side ditches.

Gravel Road.—A gravel road will not compact without months of traffic, no matter how well it has been rolled during construction, and maintenance work should begin immediately the road is open for traffic. As with any type

Grader at Work.

of road, the method of construction determines its length of life. A gravel that is dumped along the road in numerous piles with no care taken to spread or shape it, simply makes it that much more inconvenient to the travelling public.

The drainage should first be given consideration; the ditches, the culverts, waterways of all descriptions must have free and unobstructed outlets. The fact that we are simply going to construct a gravel road does not lessen the liability. This province at the present time has a considerable mileage of properly constructed gravel road that favorably compares with our macadam. The life of the gravel road depends upon the drainage and foundation. A road that is properly graded and ditched adds considerably to the appearance of the country in general.

The preparation of the subgrade depends partly upon the traffic expected and partly upon the amount of money to be expended. Proper alignment having been secured, the surface is brought to grade by use of grader wheel, scraper and roller. There are two methods of construction generally used,—surface and trench. The surface method consists of bringing the roadbed to the proper grade, as explained above, and placing the gravel upon it, care being taken to draw all large stones to the centre of the road that they may be covered by following material. The road is then rolled or allowed to be consolidated by traffic. The trench method is a little more expensive. A trench is made along the centre of the road, material being moved to the sides to act as shoulders to keep the gravel in place. The gravel is then placed upon the road, evenly spread and rolled. When second course of material is applied it is of sufficient depth to spread slightly over shoulders making a more even and better wearing surface. It has been claimed that no advantage results from rolling but certainly the public will not drive on the side of the road, cutting the shoulder away if its surface is rolled and put in proper shape. Gravel roads so far in Ontario have not been constructed with addition of bituminous material. They have, however, been built in the States but not with the same success attending the use of stone. The gravel with its rounded pebbles does not consolidate and bind together as with the angular and irregular shaped material.

To maintain a gravel road the same system of patrol applies as in macadam, the ruts must be kept filled and the surface smooth. The road drag is probably the best tool for this purpose, particularly the first year after construction, when it should be used after wet weather while the road is in a soft condition. The road drag will not have the same effect as the road ages, unless a period of wet weather exists for some time. Patching should be done when the road is in a wet condition as the new material added will bond to the old and compact much better than when in a dry state. It is also easier to locate bad places by the standing water. Care should be taken in filling these holes that the material is only raised above the surrounding surface sufficient that upon consolidation the new surface is level. Patching and the road drag, with attention to ditches and culverts, will keep a gravel road in condition until it needs resurfacing.

WEEKLY RAILWAY EARNINGS.

The following are the weekly earnings of Canada's transcontinental lines during April:—

Canadian Pacific Railway.

	1917.	1916.	Inc. or dec.
April 7	$2,830,000	$2,482,000	+ $348,000
April 14	2,833,000	2,577,000	+ 256,000
April 21	2,708 000	2,343,000	+ 365,000

Grand Trunk Railway.

April 7	$1,215,768	$1,155,486	+ $ 60,282
April 14	1,103,119	1,024,505	+ 78,616
April 21	1,085,031	1,059,661	+ 25,370

Canadian Northern Railway.

April 7	$ 736,200	$ 677,000	+ $ 59,200
April 14	881,600	668,900	+ 212,700
April 21	765,600	634,300	+ 131,300

An association, to be known as the Society of Terminal Engineers, has received a charter, under the laws of New York State, for the purpose, among other things, of promoting the study of terminal engineering and mechanical freight handling.

From a study made of the water supply for the Panama Canal it has been ascertained that an average of 7.21 million cubic feet of water was used for each through lockage from ocean to ocean; that an average of 12,787.47 million cubic feet of water was wasted over Gatun spillway, or a sufficient quantity of water to make 1,773 through lockages each month. Based on 30-day operation, this would mean 59 lockages per day over and above the average traffic for the past year. According to the latest annual report of the Governor of the Panama Canal, the maximum number of lockages which can be made in 24 hours is 48, assuming that one vessel leaves the upper flight at Gatun just as another enters the lower chamber, and vice versa, both chambers being used.

Editorial

WATER WASTE.

In many of our cities and towns there appears to be little or no attempt at conservation of water. Those who are opposed to the metering of water, claim that it would not be in the interests of public health to do anything which would in any way cause consumers to economize in the legitimate use of water. That objection may appear to be well taken but, on the other hand, there is ample evidence, as disclosed by reports of not a few municipalities in Canada and elsewhere, that so long as there is water in the reservoir the profligate waste goes on unchecked. In fact, lack of judgment in this respect has frequently caused alarm and danger.

Considering that the majority of water supplies throughout the country have to be pumped once and sometimes twice, that many of them are filtered and some of them chemically treated, is it just fair that water should be regarded "as free as air"? Is it not in reality a manufactured product with manufacturing costs accompanying it?

In this connection it is interesting to note the results of an experiment which was carried on in Philadelphia some time ago. That city had for long been regarded as the most pronounced sinner among the larger cities, so far as wastage of water was concerned. An ordinance was secured permitting the installation of meters. A vigorous house-to-house inspection was inaugurated. Thousands of leaky fixtures were located and repaired.

This was followed by a very determined campaign for the detection and repair of leaks in mains.

By the elimination of this waste Philadelphia has been able to add materially to its water pressure both for fire and municipal purposes.

On a smaller scale many other municipalities are just as guilty as Philadelphia was before it tackled the problem in an aggressive and business-like manner.

The season of the year is upon us when there is a tendency to be more lavish in the use of water for sprinkling lawns, etc., and the problem of water conservation will no doubt force itself again upon the attention of municipal engineers and waterworks officials.

HOW LONG WILL THE WAR LAST?

A well-posted American, with a knowledge of German conditions, last month predicted the end of the war within sixty days. His judgment was based upon the acute financial condition of the Central Powers. The popular forecast, which has a habit of changing as rapidly as events move, is that the struggle will end in October. This has received a measure of support in the statement of the Right Honorable William Hayes Fisher, in an address in England last month, in which he said: "We did not intend to stand more than three years of war. Germany's idea was to starve us out before we could knock her out. What we want is to knock the enemy out this year, and we are beginning to do it."

In his latest book, Mr. H. G. Wells, who still believes "in the western push, if only we push it for all we are worth," says the war may go on into 1918 or 1919. Food riots, famine, and general disorganization will come before 1920 if it does. Mr. Wells discusses his subject after a tour of Italy, France and Great Britain. It is the lack of public knowledge of actual conditions in Germany, however, which largely prevents everyone from making predictions of value as to the war's end. This deficiency is supplied to some extent by Oscar King Davis, for some months staff correspondent of the New York Times in Berlin. He returned with Ambassador Gerard. That there is practically complete solidarity in Germany concerning the war, is a fact which Mr. Davis claims is the main element in Germany's strength.

After analyzing the situation there, he says: "Germany may go on for a year or even a little more. Then it may be want of food, or money, or men, or all together that brings her down. Always provided that her foes are able to go along at the same speed they are now showing. I do not believe that Germany can last much, if any, more than another year. If the Entente Allies can outlast that, I believe they can bring Germany down. If Germany has bad crops this year, it will be comparatively easy. If she has good crops, it will be more difficult, but still I believe it will be done, for her financial needs are driving her even more inexorably than her food situation, and no help is in sight for that."

In short, the Central Powers are weakening rapidly; the Allies are increasing in strength, and have received an important additional reinforcement by the United States war declaration.

KITCHENER, ONTARIO.

In Ontario, there was a town of Berlin. Some of its residents are of British and some of German stock. Most of the German stock there are good Canadians. Some have German sympathies. Those sympathies were organized and active. So we had a Canadian town which, though it flew the Union Jack, harbored German sympathies and certain other characteristics which are not recognized in a British country. That this sentiment is widespread was evident whenever Berlin travellers went out to sell goods. They were told to get out of the buyer's office. A movement was initiated to change the name of the town to Kitchener. This was done after considerable opposition which, unfortunately, was slapped with a political hand instead of being stamped with a British foot.

Merchants know that Kitchener was once Berlin and they have boycotted the industries in that town. Being distant buyers, they could not always know who are the Kitchener firms believing in British ideals. So that these firms may not suffer for the acts of any pro-Germans who may still exist in Kitchener, there has been established the Kitchener Manufacturers' Association of the British League. Its members are manufacturers who fought for the city's change of name and opposed all efforts to retain the name Berlin. The new organization has its

own trade mark, which is reproduced here. This will be attached to all shipments made by its members. The merchants of Canada will make no mistake in patronizing firms whose goods bear this trade mark, for it signifies that those firms have done unpleasant but necessary work in combatting an undesirable influence in a British Dominion.

PERSONAL.

ALEXANDER ALLAIRE, M.E., M.Can.Soc.C.E., formerly manager of the Foundation Co., Limited, and latterly a member of the engineering staff of the Foundation Co. of New York City, has resigned from that company to become vice-president of Fraser, Brace & Co., contractors, 1328 Broadway, New York.

HARRY DARLING, formerly manager of the Dome Lake mines in Porcupine, Ont., has left for California, where he will look after the Crown Reserve interest at the Globe mine. RALPH REGNALL is now manager of the Dome Lake mines.

Lieut. CHARLES S. DeGRUCHY, B.Sc., Montreal, a junior member of the Canadian Society of Civil Engineers, has been slightly wounded at the front. In February he was awarded the Military Cross. Prior to joining a draft of the field artillery he was assistant engineer at the Halifax Ocean Terminals.

HORACE J. EASTMAN, mining engineer of Rossland, B.C., has enlisted for active service in the Universities platoon.

THOMAS FINDLEY, former vice-president and assistant general manager of the Massey-Harris Company, Limited, Toronto, has been elected president and general manager to succeed the late Sir Lyman Melvin-Jones.

EDWIN ROY GRAY, B.A.Sc., formerly deputy city engineer and latterly joint manager of the works department at Hamilton, Ont., has been placed in charge of the works department of Hamilton with the title of city engineer and manager of the waterworks and sewage disposal works.

JOHN H. GREGORY, M.Am.Soc.C.E., announces that the firm of Hering & Gregory, consulting engineers of New York City, has been dissolved. Mr. Gregory will continue in practice as a consulting hydraulic and sanitary engineer.

E. A. HAMEL, A.M.Can.Soc.C.E., has been appointed on the permanent engineering staff of the city of Quebec, as assistant to City Engineer W. D. Baillairge.

Brigadier-General F. O. W. LOOMIS, D.S.O., of D. G. Loomis & Sons, contractors, Montreal, has been awarded the Colonial Officers' Decoration for long service. General Loomis was recently wounded, but has now resumed his duties at the front.

F. L. MacPHERSON, M.Can.Soc.C.E., for the past eight years municipal engineer for Burnaby, B.C., has resigned to accept a provincial government appointment as engineer for engineering district No. 5, which includes the electoral districts of Revelstoke, Slocan, Rossland, Trail and Kaslo. Mr. MacPherson is an associate member of the Institute of Civil Engineers of Great Britain.

S. L. SQUIRE, of Waterford, Ont., has been appointed by Hon. F. G. Macdiarmid, Minister of Public Works, Ontario, to the position in the Highways Department of municipal adviser. He is a former president of the Ontario Good Roads Association.

F. TISSINGTON, chief engineer of MacKinnon, Holmes & Co., Limited, Sherbrooke, Que., has resigned his position and is taking a short holiday before commencing work again.

A. R. WHITELAW, who for the past year has been engineer in charge of the construction and equipment of a new boxboard plant for the Northumberland Paper & Electric Company, Limited, at Campbellford, Ont., will supervise the construction and equipment of the power house for the Hydro-Electric development on the madawaska River at Calabogie, Ont.

OBITUARY.

HARRY GOULDING AKERS, son of the late John Akers, K.C., Toronto, and a graduate of the School of Practical Science of the class of 1907, died suddenly of heart failure at Yorktown, Virginia, at the age of 30. When war broke out he volunteered for active service, but was rejected. He then went to the United States, where he was employed with munition firms.

Lieut. J. D. ARMSTRONG, of the Topographical Surveys Branch, Department of the Interior, Ottawa, has been killed in action. After graduating from McGill University he was connected with the Grand Trunk Pacific in construction work. He was a student member of the Canadian Society of Civil Engineers.

S. R. BADGLEY, who designed Massey Hall, Toronto, died recently in Wycliffe, Ohio, near Cleveland. Mr. Badgley had reached an advanced age and was looked upon as one of the leading architects in the middle States.

D. McKAY, general superintendent of the Yellowhead Pass mines, Alberta, was killed recently by a fall of coal in No. 5 mine. The deceased was well known in mining circles around Edmonton, being formerly in charge of the Twin City mines, Edmonton.

JOSEPH ROVER ROY, A.M.Can.Soc.C.E., for twenty-one years a civil engineer in the employ of the Public Works Department, Ottawa, died on April 25th. He had been ailing for some weeks. The deceased was born in Montreal, the son of the late Rover Roy, Q.C., for many years city attorney of Montreal.

DEGREES CONFERRED BY UNIVERSITY OF TORONTO.

The following have been granted degree of B.A.Sc. with honors by the faculty of Applied Science, University of Toronto:—

Civil engineering—H. A. Babcock, A. E. Berry, R. S. C. Bothwell, F. C. Christie, R. W. Hurlburt, R. C. Manning, R. D. Ratz, C. E. Tilston, V. Topping.

Mining engineering—H. L. McClelland.

Mechanical engineering—A. M. Snider.

Architecture—A. S. Mathers, H. R. Watson.

Applied chemistry—J. V. Dickson.

Electrical engineering—W. A. R. Offerhaus, A. A. Tufford.

The degree of Civil Engineer (C.E.) was last week conferred by the University of Toronto upon Messrs. C. J. Townsend and Thomas Taylor, Toronto, and W. C. Smith, Victoria, B.C.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

RAILWAY ENQUIRY COMMISSION'S REPORT

STARTLING FACTS BROUGHT OUT BY MAJORITY REPORT—G.T.R. AND C.N.R. SAID TO BE UNABLE TO SURVIVE—HUGE SUMS MUST BE SPENT IMMEDIATELY FOR EQUIPMENT AND REPAIRS—NEW RECORD ESTABLISHED FOR VALUATION WORK

SIR Henry L. Drayton and Mr. W. M. Acworth, two of the three members of the Royal Commission to Inquire into Railways and Transportation, have submitted to parliment a majority report advocating that the government take over the Grand Trunk, Grand Trunk Pacific and Canadian Northern Railways and transfer them to a board of five trustees who shall operate them independently of the government. They also recommend that the Transcontinental, Intercolonial and Prince Edward Island Railways should be transferred to the trustees. The Dominion Railway Company, which is the name under which the trustees would probably operate, would control twenty thousand miles of railways, and would be the largest system in the world not state-operated, and second only to the government-operated German system.

Mr. Alfred Smith, president of the New York Central Lines, who is the third member of the commission and its chairman, submits a minor report dissenting from many of the views of his colleagues and advising the government to leave the railroads in private hands and to continue financial assistance from time to time as required. He states, however, that the systems should not be left as they are, but recommends the transfer to the Grand Trunk of all the Canadian Northern's eastern lines and the transfer to the Canadian Northern of all the Grand Trunk's western lines, including the Grand Trunk Pacific and its branches.

The majority report is a printed document of ninety pages, 6½ ins. x 9¾ ins., regulation government blue-book size and style, and is accompanied by two appendices,—one twelve pages long reviewing the evidence heard by the commission in its examination of Mr. E. J. Chamberlin, of the G.T.R., at Montreal on February 24th, 1917; the other, occupying seventy-four pages, presenting Prof. Swain's report on physical valuations. The minority report requires only fifteen pages, presenting no statistics and being largely commentary upon the majority report.

In addition to a short introduction and to a summary of conclusions and recommendations, the majority report is divided into six main parts.

Part I. deals with Canadian railways in general, giving mileage, capital and state aid, apportionment of mileage, gross and net revenue, investment in road and equipment, return on capital, government aid in general, government aid to Canadian Northern, government aid to

Table Indicating Prospects of the Proposed Railroad Merger

FROM REPORTS TO DEPARTMENT OF RAILWAYS AND CANALS, JUNE 30, 1916 (EXCEPT G.T.P. BRANCH LINES)

—	Can. Northern	Grand Trunk	Grand Trunk Pacific	G.T.P. Branch Lines	Intercolonial	Transcontin'nt'l	Total
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Operating revenues	35,476,275 06	39,155,040 10	6,963,188 88	1,319,599 16	15,686,661 91	5,798,516 09	104,399,281 20
Operating expenses	25,244,186 12	28,782,012 69	5,902,843 30	1,370,133 51	13,323,183 16	5,360,061 58	79,991,420 36
Net operating revenue	10,232,088 94	10,373,027 41	1,060,345 58	Loss 50,534 35	2,363,478 75	429,454 51	24,407,860 84
Outside operations	.....	.....	10,588 55	.....	.....	.....	10,558 55
Taxes	741,508 11	853,596 39	.....	.....	.....	.....	1,595,104 50
Operating income	9,490,580 83	9,519,431 02	1,070,904 13	Loss 50,534 35	2,363,478 75	429,454 51	22,823,314 89
Other income	.....	3,634,123 65	.....	.....	.....	37,680 84	3,671,804 49
Gross income	9,490,580 83	13,153,554 67	1,070,904 13	Loss 50,534 35	2,363,478 75	466,135 35	26,495,119 38
Interest on funded debt	9,885,153 14	7,644,631 07	.....	.....	.....	.....	17,529,784 21
Other charges	506,010 29	2,415,539 70	.....	.....	167,214 29	808,750 86	3,897,515 14
Dividends	.....	†2,433,333 33	.....	.....	.....	.....	2,433,333 33
Total income deduct'ns	10,391,163 43	12,493,504 10	.....	.....	167,214 29	808,750 86	23,860,632 68
Surplus & loss for year	Loss 900,582 60	660,050 57	*1,070,904 13	Loss 50,534 35	2,196,264 46	Loss 342,615 51	Surplus— 2,633,486 70
Profit and loss items	267,885 85	.....	.....	.....	.....	.....	Deduct— 267,885 85
							Surplus— 2,365,600 85
Add Interest to be provided for	5,445,389 56	.....	6,668,084 04	538,760 16	.....	.....	12,652,233 76
Add Estimated loss, Prince Edward Island Railway	.....	.....	.....	.....	.....	.....	250,000 00
Total Deficiency	.....	.....	.....	.....	.....	.....	10,536,632 91

*Before charges. †Div. on guaranteed stock.

Canadian Pacific, government aid to Grand Trunk, government aid to Grand Trunk Pacific, total public investment, proportion of public investment, and historical development and growth of Canadian railways.

Part II. deals with the Grand Trunk System, the chapter headings being: G.T.P. Finance, Grand Trunk Liability for G.T.P., Grand Trunk Co.'s Proposal, Grand Trunk Case, Inception of the National Transcontinental, Letter from the President of the Grand Trunk, Hearing of Grand Trunk Officials at Montreal, G.T.P. Case, Commission's Conclusions, Parent Grand Trunk Co., Grand Trunk Maintenance Expenditure, Grand Trunk Capital Expenditure Required, Effect on Canadian Business, and Commission's Recommendation.

Majority Report Divided Into Six Main Parts.

The Canadian Northern System is fully dealt with in Part III., which reviews the C.N.R. position in 1914, the annual report for 1916, C.N.R. estimates for 1914 and 1917, comparison with Canadian Pacific, prospective requirements of C.N.R., value of Canadian Northern undertaking (1. cash investment; 2, physical basis; 3, going concern), and conclusions as to Canadian Northern.

Possible methods of public control are reviewed in Part IV. of the report and government operation is discussed and rejected. An obstacle created by the Canadian Pacific position is discussed. Receivership is considered but rejected and transfer to a new body is recommended. Suggested transfer of all railways to the Canadian Pacific or of a whole or portion of the C.N.R. to Canadian Pacific is discussed and rejected. The possibility of forming a commercial company along the lines either of the Mexican precedent or the New York Subway precedent is considered but not favorably. "Canadian Railways Should Be Under Canadian Control," is the title of the last chapter of this part.

The longest portion of the report is Part V., outlining the Dominion Railway Co. The headings of the chapters in this part of the report are as follows:—

Dominion Railway Organization Recommended.

Government Operation Not Recommended, Recommendation of Independent Board of Trustees, Constitution of Board and Tenure of Office, Board to be Non-Political, Board to be Permanent and Self-Perpetuating (including a review of Australian experience), Railways Not a Proper Subject for Direct Parliamentary Control, Growth of Extra-Parliamentary Functions of the State, Private Interests and Public Interests, Control of Dominion Railway by Railway Commission, Relation Between Trustees and their Employees, Incorporation of the Dominion Railway Co., Transfer of Stock to Trustees, Transfer of Railways to Trustees, Canadian Northern Shareholders, Charges of Misappropriation Unfounded, Canadian Northern Successes and Failures, Arbitration Recommended, Grand Trunk Shareholders, Terms of Purchase Recommended, Real Value of Grand Trunk Property, Intercolonial and National Transcontinental, Transfer of National Transcontinental Recommended, Transfer of Intercolonial Recommended (1, in the local interest; 2, in the general interest; 3, in the interest of good management), Minor Recommendations, Legal Position of Trustees, Operation of Dominion Railway Co., Finance of Dominion Railway Co., Operation to be on a Commercial Basis, Wide Powers to be Given to Trustees, Financial Responsibility of Government, Prospects of Dominion Railway, and Specimen Economies Resulting from Combination.

The sixth and last portion of the report touches briefly upon a wide variety of subjects kindred to the main investigation. It advocates railway commission control of the Dominion Railway Co., and suggests that the commission's jurisdiction be enlarged to report on new charters and on subsidies and guarantees. Overlapping of Dominion and Provincial control is condemned. It is recommended that a running audit be made of the Dominion Railway accounts and that the accounts be published in clear form, so that the taxpayers will know exactly where the government stands.

Railway councils similar to those held under the German system are recommended for future organization. Railways in excess of existing requirements are discussed. Attention is called to the necessity of improvement of highways as feeders to the railways. The Hudson Bay Railway is discussed and practically condemned. The commission were asked to report on steamship connections, but have not touched upon this subject on account of the very short time at their disposal and the complete revolution in the shipping trade caused by the war. The public is warned that the tendency of railway rates is to rise rather than fall. The report ends with a strong plea for immediate action.

The following are the conclusions and recommendations contained in the report as officially summarized by Sir H. L. Drayton and Mr. Acworth:—

Summary of the Drayton-Acworth Conclusions and Recommendations

1. The mileage of Canadian railways is very great in proportion to the population of the country. It has increased out of proportion to the increase of population.

2. Canada's natural waterways make railways less absolutely necessary than in other countries.

3. The net return is so low as to prove that more railways have been built than can be justified on commercial grounds under present conditions.

4. The public investment in railways is very large. The total amount of public capital involved in direct construction of Government lines, and cash aid, land grants and guarantees to private companies, is $968,451,000, not counting the value of lands still unsold.

5. Public aid to the principal companies, including subsidies, land grants, and guarantees, amounts to over $680,000,000. In the case of the Grand Trunk Pacific it amounts to nearly two-thirds of the total investment; in the case of the Canadian Northern to over three-quarters.

6. There have been three phases of company development: (1) Unaided enterprise, (2) assistance by subsidies and land grants, (3) assistance by guarantees. A guarantee policy is dangerous and its wisdom questionable.

7. The development of Canada justified two transcontinental lines. It did not justify three. The Grand Trunk and Canadian Northern should have been amalgamated.

8. The Grand Trunk Pacific system has cost nearly $200,000,000. The interest charges amount to over $8,800,000 per annum. The net income last year was $820,053. The liability of the Grand Trunk Company for interest amounts to over $5,000,000 per annum at present, and will rise to over $7,000,000 in 1923.

9. We cannot recommend that the Grand Trunk Company be unconditionally released from their liability. The responsibility for the National Transcontinental line

rests mainly with the Government, but that for the Grand Trunk Pacific proper belongs primarily to the Grand Trunk. The Government has voluntarily relieved the Grand Trunk of all responsibility for the National Transcontinental. In respect to the Grand Trunk Pacific proper the Government is fully entitled, morally as well as legally, to call upon the Grand Trunk Company to fulfil its contract.

10. The Grand Trunk Company proper has made unjustifiable charges to capital. Its lines have not been adequately maintained. More than $21,000,000, which ought to have been spent on maintenance in past years, has not been spent. New capital expenditure of over $30,000,000 is immediately required. The country is suffering from the company's inability to give adequate service. The Grand Trunk Railway ought to be managed in Canada, and not from London.

11. We recommend that the control both of the Grand Trunk Pacific and of the Grand Trunk be assumed by the people of Canada on terms hereafter set out.

12. The Canadian Northern has been financed mainly by the issue of guaranteed securities. Till 1914 it met the interest from its own resources. Since that date the Government has assumed very heavy obligations on behalf of the company. There is little prospect that the company would be able in the near future to relieve the Government of these obligations.

13. The company's estimate of its future capital requirements is too low; and its estimates of probable growth of earnings have been and still are unduly sanguine.

14. We estimate that as a separate undertaking it would require fully $70,000,000 of new capital within the next five years.

15. We do not recommend that further public aid be given to the Canadian Northern as at present constituted.

16. The Canadian Northern common stock represents no cash investment, and has no present value, either on the basis of the cost of reproduction of the property or on the basis of its earning power.

17. We recommend that the public take control of the Canadian Northern Company on terms hereafter set out.

18. On the assumption that the people of Canada take control of the Grand Trunk, Grand Trunk Pacific and Canadian Northern, we consider possible methods of management and operation.

19. We do not consider that operation by a minister directly responsible to Parliament would be in the public interest. It would not secure better service or lower rates.

20. If the Government operated these three railways, it would be bound in fairness to the Canadian Pacific shareholders to take over their railway also. The Canadian Pacific gives good service and should not be interfered with.

21. Special objections to direct Government ownership and operation are:—

(1) That Canadian railways operate more than seven thousand miles of line subject to the foreign jurisdiction of the United States;

(2) That the Canadian Government resources are required for war purposes.

22. We, therefore, reject the idea of direct Government ownership and operation.

23. We do not recommend that the Grand Trunk, Grand Trunk Pacific and Canadian Northern Companies be allowed to go into the hands of a receiver.

24. We recommend that the control of these three companies be transferred to a new body.

25. We have discussed and rejected the following suggestions:—

Transfer of all three railways to the Canadian Pacific.

Transfer of the Canadian Northern or a portion of it to the Canadian Pacific.

26. There is no possibility of forming a new commercial company to take over the three railways. Neither the Mexican precedent, under which the Government becomes a majority shareholder, nor the New York Subway precedent, under which the public authority shares the profits with the private shareholder, is applicable to this case.

27. Having come to the conclusion that direct ownership and operation by the Government is to be avoided, and that ownership and operation by a commercial company is not possible, we recommend that a new public authority, a Board of Trustees, be incorporated by Act of Parliament as the "Dominion Railway Company"; and that the Canadian Northern, Grand Trunk and Grand Trunk Pacific be transferred to this body.

28. We recommend that the Government assume responsibility to the Dominion Railway Company for the interest on the existing securities of the transferred companies.

29. We recommend that the Intercolonial and National Transcontinental be also transferred to the Dominion Railway Company for reasons which we give hereafter.

30. We recommend that the whole of the Dominion Railways be operated by the Trustees as one united system, on a commercial basis, under their own politically undisturbed management, on account of, and for the benefit of, the people of Canada.

31. We recommend that there be five Trustees, three railway members, one member selected on the ground of business and financial experience, and one as specially possessing the confidence of railway employees; that the original Trustees be named in the Act constituting the Board; and that their tenure of office be substantially the same as that of judges of the Supreme Court.

32. We recommend that the original Trustees retire after three, four, five, six, seven years, respectively, according to a prescribed scheme; that they be eligible for reappointment; and that all appointments subsequent to the original statutory appointments be by the Governor-General-in-Council on the nomination of the Trustees themselves.

33. We lay stress on the importance of the Board being non-political, permanent, and self-perpetuating; and in this connection point to the experience of the Australian State Railways.

34. We give reasons for concluding that railways are not a proper subject for direct parliamentary control. We point to a general tendency in modern democracies to withdraw certain subjects from this control. And we show that under parliamentary control the general interest of the whole community tends to be subordinated to the particular local and individual interests.

35. We recommend that the authority of the Railway Commission be extended to include the Dominion Railway Company's system.

36. We give the reasons for our recommendation that one of the Trustees shall be appointed on the ground of his possessing the confidence of the railway employees.

37. We recommend the transfer to the Trustees of the common stocks of the Canadian Northern, Grand Trunk and Grand Trunk Pacific, subject to certain conditions and reservations made hereafter.

38. We recommend the transfer to the Trustees of the Intercolonial and National Transcontinental Railways for reasons which we give hereafter.

39. We deal with the question of the compensation to Canadian Northern shareholders. We find the charge that Messrs. Mackenzie and Mann have misappropriated public moneys unfounded. We find that the Canadian Northern shareholders possess a system of which the lines are well located and economically constructed, and that they have raised the necessary money with considerable financial skill and at moderate rates of interest, but that they erred in unwisely duplicating lines and reaching out into unremunerative territory.

40. We recommend that the question be considered whether Canadian Northern shareholders shall be permitted to retain a moderate proportion of the $60,000,000 shares which they now hold; that the precise proportion, if any, and the relation of that proportion to their share of any future profits of the Dominion Railway Company, be fixed by arbitration.

41. We recommend that the entire share capital of the Grand Trunk, guaranteed, preference and ordinary, be surrendered to the Trustees in exchange for an annuity based on a moderate but substantial proportion of $3,600,000, the average sum paid as dividend in the last ten years; and that this annuity should increase by 40 or 50 per cent. after the first seven years.

42. We recommend that the precise figure be fixed by agreement, and that it be left to the directors of the Grand Trunk Company (1) to apportion the annuity among the five classes of Grand Trunk shareholders, and (2) to procure such assents of their shareholders as are legally required to complete the transfer.

43. We give reasons for considering that this recommendation is generous to the Grand Trunk shareholders, and why the shareholders in their own interest will do well to accept it.

44. We recommend the transfer to the Trustees of the National Transcontinental, in order that it may take the place it was built to take as part of a great inter-ocean highway, and because its financial position would be hopeless if it terminated in a dead end at Winnipeg.

45. We recommend the transfer of the Intercolonial: (1) In the interest of the Maritime Provinces, to whom the Intercolonial at present can only give a local service with no adequate terminals beyond Montreal; (2) in the interest of the taxpayer, who has a right to demand efficient and economical expenditure of his money; (3) in the interest of the railway staff, who will secure the wider opportunities of a great system.

46. We recommend that in future the Intercolonial be required to pay local taxes on the same basis as the other railways; and that the inhabitants on the line receive statutory protection against increase of local railway rates.

47. We make recommendations as to (1) non-railway property of the transferred undertakings, (2) getting in minority holdings of shares and outstanding titles to land, (3) arrangement with the holders of Canadian Northern 5 per cent. convertible income debentures.

48. We deal with the legal position of the Trustees; and point out that the Canadian Northern, Grand Trunk and Grand Trunk Pacific companies will continue to exist; and that consequently the rights of their security holders will remain undisturbed.

49. We recommend that the Trustees take over each railway as soon as the transfer can be effected, with the purpose of ultimately operating them all as a single unified system.

50. We deal with the finances of the Dominion Railway Company and point out that the Intercolonial, with no bonded indebtedness, has a considerable net revenue, and offers security on which new capital can be raised. We recommend the creation of a general and refunding mortgage of unlimited amount, to be issued as required.

51. We recommend that the Act of Parliament provide that the operation of the company shall be on a commercial basis, and that the Trustees make no general reduction in rates until the property earns a reasonable net return.

52. We recommend that there be given to the Trustees the widest powers in the management of their property.

53. We have endeavored to estimate the annual liability of the Government to meet interest unearned during the first few years of the new scheme, and we put it at about $12,500,000 per annum. We think this amount should diminish steadily but not slowly; and that with proper economic and politically undisturbed management the attainment of a satisfactory financial result is only a question of time.

54. We give specimens of the large economies which should result from combined operation.

55. We recommend the enlargement of the functions of the Railway Commission; that it have jurisdiction over all Dominion Railways; and report to Parliament on all proposed grants of charters, subsidies, and guarantees.

56. We deal with the conflict of Dominion and Provincial jurisdictions. We recommend that, to prevent this in future, the Governor-in-Council should in certain cases disallow Provincial Acts, and that no railway company should operate under both Dominion and Provincial charters.

57. We recommend that there be a continuous public audit of the Dominion Railway accounts, and that full and comprehensive reports be made annually to Parliament.

58. We recommend the establishment of Railway Councils to bring together the railway management and representatives of public interests.

59. We point out that the existing railways are in excess of public requirements and show how much traffic is required to make a railway profitable.

60. We show that the cost of hauling grain to the station is sometimes as great as that of carriage from the station to Liverpool, and recommend that the question of highway improvement and motor haulage be taken into consideration.

61. We recommend that future expenditures on the Hudson Bay Railway be reduced to the lowest possible amount.

62. We point out that railway rates are much more likely to rise than to fall in the immediate future.

63. And finally, we lay stress on the necessity for immediate action lest Canada should suffer from railway congestion even worse than that of the past winter.

Position of Grand Trunk Railway— G.T.P. was the Fatal Mistake

From the majority report it appears that government aid to the Grand Trunk amounts to $28,145,693, and to the Grand Trunk Pacific $114,470,884, and to the Grand Trunk Pacific Branch Lines $13,469,004. This includes subsidies and other cash aids as well as guarantees on bonds, and includes all provincial and municipal aid as well as Dominion government aid.

No physical valuation was made of the Grand Trunk System proper, as with the time at the disposal of the commission it was possible to make a physical valuation only of the Canadian Northern and Grand Trunk Pacific. Besides, it was thought that no useful purpose could be served by a valuation of the Grand Trunk Railway proper, the view being taken that the G.T.R. has been in operation for such a length of time that its value is best established from its earnings. These earnings, say the commissioners, must also be greatly discounted, owing to the commitments of the G.T.R. in Grand Trunk Pacific projects, amounting to $123,280,980. The G.T.R. stands as guarantor of $97,301,252 bonds and debentures of the G.T.P., and in addition have advanced $26,179,728 in cash. The present annual liability of the Grand Trunk in connection with the G.T.P. System is considerably over five million dollars per annum and in January, 1923, it will be increased to seven million dollars. The difference is on account of the Dominion Government's obligation to pay the interest on the government-guaranteed first mortgage bonds of the mountain section of the G.T.P., amounting to $1,655,121 per annum for seven years after the completion of the road, which was officially January 1st, 1916.

The Grand Trunk Railway has not been and is not being adequately maintained, says the majority report. No depreciation fund has been created for equipment. Mr. Chamberlin's evidence is that 5 per cent. on the cost of the equipment ought to be annually charged under that heading. This item, he says, would have required an annual sum of $2,750,000. The vice-president in charge of operation, Mr. Kelley, has direct responsibility for the plant. He agreed with Mr. Chamberlin's evidence and submitted a full report on the question of deferred expenditure, as follows:—

G.T.R. Summary of Deferred Expenditures.

Rebuilding and reinforcing freight car equipment		$ 8,943,971.14
Equipping freight and passenger cars with safety appliances—		
Original estimate	$850,722.50	
Already expended	392,220.89	
Balance to be expended		458,501.61
Equipping engines with safety appliances—		
Original estimate	$ 17,828.00	
Already expended	553.68	
Balance to be expended		17,274.32
Deferred renewals in Maintenance of Way Department—		
In Canada	$6,182,672	
In United States	5,578,926	
		$11,761,598.00
Total		$21,181,345.07

Montreal, March 5, 1917.

On the single item of rails the cash expenditure required to restore normal conditions is reported as $5,312,142. The cost of restoring ballast to normal conditions is reported as $2,434,000. With reference to "deferred renewals" in Canada, amounting to over six million dollars, it appears that they have accumulated during eleven years, 1906-1916, "during which period, in spite of the requirements of the property and the claims of public safety, $36,000,000 were paid out in dividends," says the report.

$21,000,000 Needed Now for G.T.R. Maintenance.

"The twenty-one million dollars dealt with above," says the report, "represent the money which the responsible officers of the company estimate to be required to put the existing plant into good normal condition. This is a revenue liability. But the existing plant is quite inadequate for existing traffic and requires large additions, for which new capital must be raised. The estimates of necessary capital expenditures submitted to us are as follows:—

"Requirements for rolling stock, shops and machinery	$26,150,000
"Requirements for automatic block signals (main line in Canada only)	3,533,000
"Requirements for installing rock ballast crushing plant	467,500
"Total	$30,150,500

"Putting together revenue and capital expenditure, we find that the Grand Trunk Railway, in the opinion of its own officers, requires over $51,000,000 spent upon it to put it in a position to meet the requirements of its to-day's business. We see no reason to expect that under existing conditions this necessary money will be provided. The effect on the country's business of deficient railway facilities is very serious.

"The Grand Trunk Company's Board of Directors is 3,000 miles away. We cannot think that the state of affairs which our investigation has disclosed could have arisen, had the Board been on the spot. We are forced to the conclusion that the control of an important Canadian company should be in Canada. But this cannot be secured as long as the Grand Trunk Railway is owned by shareholders in England. We have come to the conclusion, therefore, that the control, not only of the Grand Trunk Pacific Company, but also of the Grand Trunk Company of Canada should be surrendered into the hands of the people of Canada. We recommend that the chairman of the Grand Trunk Company be informed, that it is only on this condition that the Government is prepared to relieve his company of the obligations which it has incurred in respect to the Grand Trunk Pacific. We recur later on in this report to these two companies, in order to set out our recommendations as to their ownership and management in the future, and as to the terms to be offered to the Grand Trunk shareholders."

G.T.R. Accuses Government of Bad Faith.

The Grand Trunk have asked the government to be relieved of their G.T.P. liabilities and to have refunded to them all of the money which they have put into the G.T.P., claiming (1) that the government had in effect gone into partnership with the G.T.P., and that subsequently it had by subsidies and guarantees enabled the Canadian Northern to come into existence, and that this action of the government was, in view of its position as

partner with the G.T.P., tantamount to bad faith; (2) that the simultaneous construction of the Canadian Northern in the same territory greatly enhanced the difficulty of obtaining labor, doubled its price and also prolonged the period of construction; (3) that a new duty on steel rails was imposed after the G.T.P. Act was passed and that this added five million dollars to the cost of construction.

G.T.R. Originated the G.T.P. Undertaking.

The majority report does not accept any of these contentions. "The government was and is a government," it says, "not a mere private partner; and it retained and retains all the attributes of a government, including the power to charter new railways. We cannot suppose that the management of the Grand Trunk were ignorant of this fact when they took the act constituting the G.T.P. Co. As to (2), this no doubt was an effect which was disadvantageous to the Grand Trunk position, but the company took this risk, as it took other business risks, when it promoted its enterprise. (3) * * * The bill for the act imposing the duty was introduced three months before the agreement between the government and the G.T.P. was signed. The company, therefore, must have been aware of the government's intention. According to the correspondence, the prime minister believed in 1905 that the question of a duty on rails had been more than once discussed at the time of the inception of the scheme; Mr. Hays, for the G.T.P., believed that it had never been discussed at all."

The evidence brought out by the commission was that the Grand Trunk Pacific scheme originated with the Grand Trunk Railway, but that the government was responsible for the construction of all of the Transcontinental east of North Bay. The proposal of the company, as originally formulated, was for a line from the Pacific to North Bay. The Eastern Division, as it was then called, from Winnipeg to North Bay, was to be built by the government, and the Western Division by the Grand Trunk Pacific. The extension of the Eastern Division was entirely due to the government, but the G.T.P. concurred in it and agreed to rent the Eastern Division upon a percentage of its cost of construction. On account of the great cost of the construction of the Transcontinental, the G.T.P. refused to carry out its agreement and the government by accepting the company's refusal and commencing to work the lines themselves in effect released the company unconditionally. The line west of Winnipeg is at present being operated under the control of the Grand Trunk, the nearest point of whose rails is at North Bay, a thousand miles away.

"Financial Management Does Not Inspire Confidence."

Mr. Chamberlin, in a letter to the commission, in effect charges the government with bad faith unless the government accedes to the demands that his company be reimbursed for all G.T.P. expenditures and be allowed to withdraw from all G.T.P. obligations. "Confiscation," "crime," "repudiation of legitimate indebtedness," are among the terms used. On the other hand, the majority report says, "The Grand Trunk Pacific shareholders, in other words the Grand Trunk Co., have not shown such prudence and business foresight as would naturally encourage the government to have confidence in their future management." And again, "The financial management of the company is not such as to inspire confidence. We do not think that the credit of the Grand Trunk Co., weakened as it must be by its Grand Trunk Pacific failure, can be so maintained as to render possible the raising of sufficient capital as required."

The total issued stock of the Grand Trunk Railway is about $240,000,000, about one-half of which is preference and one-half ordinary stock. The London Stock Exchange valuation of this nominal $240,000,000 is at the present time about seventy or seventy-five million dollars, ranging from 50 for the 4 per cent. guaranteed stock, which for the past ten years has received its dividend practically in full, down to about 10 for the ordinary stock, which has never received a dividend.

The total dividends paid in the past ten years have been $36,106,439, or an average of $3,610,643 per annum. Therefore, the stock exchange valuation practically capitalizes the dividends on a 5 per cent. basis. "This in a rapidly developing country might be reasonable, if the dividends had been earned and could be maintained, but in view of the statement of the company's own officers that $21,000,000 which ought to have been spent out of the revenue for maintenance has not been so spent, it cannot be contended that the dividends have been earned. In view of the further fact that the company has to face immediate liabilities of over $5,000,000 per annum in connection with the G.T.P., and requires a capital expenditure of $30,000,000 on its own lines to put the company in proper condition to do its existing business, it can still less be contended that the dividends are maintainable."

To prevent arrears again accumulating, future charges must be $2,500,000 a year heavier than in the past on equipment alone, according to Mr. Chamberlin's judgment. Even supposing the company could raise the new capital required and only had to pay 5 per cent. for it, the additional interest charge would mean a serious reduction of the dividend, and this on the Grand Trunk lines alone, independently of the company's liabilities in respect to the G.T.P. The G.T.R. chairman has admitted that the G.T.R. are "at the end of their tether" and that it is "quite impossible for them to meet the extra liabilities arising from the G.T.P. Co."

Position of the Canadian Northern— Eastern Lines Absorb All Profits

The majority report states that the Canadian Northern System has received subsidies from the Dominion and provincial governments of $38,874,148; land grants from which $16,603,295 has been realized from sales and $17,770,514 from mortgages; loans from the Dominion government amounting to $25,858,166; and securities guaranteed by the Dominion and provincial governments to the amount of $199,141,140; or a total of public assistance, direct and indirect, of $298,253,263.

In 1914, with heavy interest payments to be made, and large construction contracts still open, the company found its resources insufficient to complete and equip its system. It estimated that it could raise on its own account $58,000,000, and appealed to the government to find the balance. An issue of $45,000,000, guaranteed by the government, yielded in cash $36,759,265, and the system was unable to sell many of the securities which it depended upon for the $58,000,000, so in May, 1916, the Canadian Northern obtained from the government a further loan of $15,000,000, and in addition the government undertook to lend the company the money necessary to pay interest either to the government itself or to the public on the $45,000,000 issue, and to date $1,756,000 has been advanced for this purpose.

According to the estimate submitted by the company, the fixed charges for the year ending June 30, 1917, will be $16,539,638, but the Dominion and British Columbia governments have undertaken to pay $4,514,507 under certain agreements. "This leaves the company to find out of net revenue about $2,500,000 more than it had available this year. An income of $2,500,000 net implies an increase of at least $9,000,000 gross, and the company itself does not venture to expect a greater increase of gross than $7,000,000.

"The above agreements to pay interest are only for two and three years respectively. The company's estimate for the year ending June 30th, 1921, is that they will then have fixed charges amounting to $18,300,000, and this burden they will have to bear unaided. (This includes interest on $2,250,000 on the new capital estimated by the company as necessary to be spent in the five years. This estimate we regard as quite inadequate.) To carry it they would need a gross revenue of $61,000,000, assuming working expenses at the moderate ratio of 70 per cent. We cannot think it safe to assume that such a result will be easy to attain.

"The Canadian Northern Railway have taken and still continue to take an unjustifiable sanguine view of its possibilities. In 1914, when the company was applying to parliament for debentures, it submitted estimates for the years 1916-18, on what was described as a very conservative basis. The estimate for gross earnings for 1916 was $54,000,000, with net earnings of $15,120,000. The fact has been that the gross earnings have been $35,476,000 and net earnings $9,373,000.

C.N.R. Did Not Meet Bonded Indebtedness.

"A further fact has been that for the year ending June 30th, 1916, interest upon $25,000,000 income debenture stock was passed, interest was charged against capital to the amount of $5,445,389, and the company was still $248,000 short of the money required to meet its bonded indebtedness.

"The company submitted an estimate to us for the five years, 1917-21. The estimate submitted to parliament for the year ending June 30th, 1917, was, gross earnings $61,000,000, net $17,700,000. The revised estimate submitted to us by the company is, gross $42,590,000, net $11,500,000. The estimate submitted to parliament for the year June 30th, 1918, was, gross $67,000,000, net $20,100,000. The revised estimate now submitted to us by the company is, gross $48,185,000, net $13,395,000.

"We think the new estimate made for us, even though more conservative than the former, is still too sanguine. We see no reason to think that the traffic will increase to any such figure as that indicated.

"We think that $40,000,000 for equipment, and perhaps $30,000,000 for additions and betterments, would be a moderate estimate of the system's needs in the next five years, assuming that the system remains separate and independent.

"We sum up the Canadian Northern situation as follows: The company is not at present able, and will not for some years to come be able, to meet its fixed charges. It will, we doubt not, increase its net earnings as the years go by. But the increased net earnings will be fully absorbed for some years to come by the interest on new capital, which must be put in, if the system is to render efficient service. The company has not now, and as far as we can see will not have in the near future, such credit as to enable it to raise the necessary capital. As we have already shown, the public investment, direct and indirect, in the Canadian Northern system amounts to $298,000,000. We do not recommend further public investment in the system, as at present constituted."

The property investment of the Canadian Northern Railway as stated in the balance sheet of June 30th, 1916, is $494,112,489. This figure has admittedly been written up to include $100,000,000 of capital stock issued without any cash consideration. "We find $37,000,000 to be maximum possible cost of the Canadian Northern system as at present existing."

Professor Swain's physical valuation of the system shows a total reproduction cost of $397,441,567. From this he deducts for depreciation $40,031,889, making the cost of the reproduction of the property in its present condition, $357,409,678. This, however, does not include equipment to the value of $56,590,418 (pre-war prices). Depreciation of equipment to the extent of $11,250,433 makes the present value $45,339,985.

C.N.R. Liabilities Equal to Its Assets?

"Putting the two valuations together, we have $402,749,663 as a fair cost of reproducing the entire physical Canadian Northern system in its present condition. Now the outstanding liabilities (bonds, debentures, notes and bank and other loans) of the company exceed $400,000,000.

"Reckoning on this basis, the liabilities are practically equal to the reproduction cost of the physical property. But the physical property does not all belong to the Canadian Northern shareholders. There are minority holdings in some of the subsidiary undertakings which imply a reduction of more than $10,000,000 in assets belonging to the Canadian Northern shareholders.

"We find, then, that on the physical basis, the value of the property of the Canadian Northern shareholders is distinctly less than the amount of the liabilities against it. On this basis the equity of the shareholders must be regarded as non-existent.

"A third basis of estimate is the value of the property for sale as a going concern. A purchaser would not consider either original cost or reproduction cost as of much importance. The price he would pay would be based on earning power, present and potential. On this basis he would consider how far the Canadian Northern is at present short of covering its fixed charges, how long it will take to reach equilibrium, how much new capital will have to be spent, how soon a dividend may be expected and at what rate. Calculating on this basis, in the light of the figures set out above, it is evident that no purchaser would offer for the property a sum amounting to the total of its liabilities.

Conclusions Regarding the Canadian Northern.

"We conclude, therefore, that the shareholders of the company have no equity either on the ground of cash put in, or on the ground of physical reproduction cost, or on the ground of the saleable value of their property as a going concern. If, then, the people of Canada have already found, or assumed responsibility for, the bulk of the capital; if they must needs find what further capital is required; and if they must make up for some years to come considerable deficits in net earnings, it seems logically to follow that the people of Canada should assume control of the property. We return later to the Canadian Northern Company in order to set out our recommendations as to its ownership and management in

the future and as to the terms to be offered to the existing shareholders."

The majority report finds that the charges of misappropriation by Mackenzie, Mann & Co. are unfounded. The sworn evidence of Canadian Northern officials shows that neither the Mackenzie, Mann Co., nor Sir Wm. Mackenzie nor Sir Donald Mann, personally, ever received a dollar from the Canadian Northern system, either as profit on contract undertakings or even as salary.

"Neither one of them have ever been a Canadian Northern voucher to the extent of one dollar," swore Mr. Hanna, the vice-president of the company. The percentage of profit which would be taken by any contractor was taken by the Mackenzie, Mann Co. entirely in common stock of the Canadian Northern Railway, and that stock represents the only profit made on all the contract work done by them on the Canadian Northern Railway. The report also finds that the road was skilfully financed and carefully and economically constructed, but that the profitable sections in the prairie provinces could not carry the unprofitable eastern extensions.

To Arbitrate Equity of C.N.R. Shareholders.

"Under the scheme we propose, the trustees will operate the Canadian Northern lines as part of a combined system. It will be impossible, therefore, for the Canadian Northern Company, as such, ever to earn a dividend on its separate stock. We suggest that, if it is decided to permit the present shareholders to retain a portion of their holding, the Act of Parliament constituting the Board of Trustees shall contain a provision for arbitration between the trustees and the Canadian Northern Company and establishing an arbitration board to act forthwith. The trustees should appoint one arbitrator and the Canadian Northern shareholders the other, and the two arbitrators should agree on the appointment of an umpire; failing agreement, an umpire should be appointed by the Chief Justice of the Exchequer Court; and the decision of the board should be final.

"The arbitrators should be empowered to decide two questions: (1) what proportion of the Canadian Northern common stock may fairly remain the property of the present holders; (2) What proportion of the earnings of the Dominion Railway Company may fairly be regarded as attributable to the Canadian Northern lines.

Must Irrevocably Deed C.N.R. to Trustees.

"To illustrate our meaning, we will assume that the arbitrators decide that 5 per cent. of the Canadian Northern shares shall remain the property of the existing holders, and further decide that one-half of the total earnings of the Dominion Railway Company will be fairly attributable to the Canadian Northern lines. Then their decision will mean that, out of any dividend declared in future by the Dominion Railway Company, 2½ per cent. (one-half of 5 per cent.) will be payable to the existing Canadian Northern shareholders or their transferees. We think the arbitrators should fix this resulting percentage once for all. It should be made a condition of the settlement that the minority shareholders of the Canadian Northern should by deed irrevocably appoint the trustees as their proxy to vote their shares. Care will of course be taken to provide that the Arbitration Board shall have regard only to the Canadian Northern lines, as they exist at the date of the passing of the Act, and that any subsequent increase of revenue due to the expenditure of additional public money shall be excluded from consideration."

Various Suggested Solutions of the Problem Are Discussed

The majority report recommends that the control of the Grand Trunk, Grand Trunk Pacific and Canadian Northern be assumed by the people of Canada. In considering how this control should be exercised, government operation was discussed and rejected for several reasons.

The opinion of the commissioners was that a receivership would be unfair to the security-holders of the companies who have a certain moral claim on the government, and would also injure the credit of Canada.

"We have recommended, then," says the report, "that the control of the three companies, Canadian Northern, Grand Trunk, and Grand Trunk Pacific pass into other hands; that the rights of the creditors of all three companies be preserved intact; but that the railways of the three companies be not handed over to, or operated by, the government. It is necessary, therefore, to find some new body or bodies to whom they can be transferred. We think the question, whether there should be one body or more, is answered by the facts that we have already recited. The Canadian Northern is weak in the East. The Grand Trunk, with the inadequate prairie branches of the Grand Trunk Pacific, would be almost powerless to compete in the West with the Canadian Northern and the Canadian Pacific. The natural tendency of the Grand Trunk and Canadian Northern organizations, if left separate, would be for each to invade the territory of the other. Remaining separate, the Canadian Northern system would need to spend many millions of dollars to obtain an adequate hold on the East in competition with the Canadian Pacific and Grand Trunk. Remaining separate, the Grand Trunk and Grand Trunk Pacific system would need to spend many millions of dollars on new branches in the West, in order to hold its own with the Canadian Pacific and the Canadian Northern. And this money would be needed at once, for till it was spent neither organization would possess a complete system. Canada cannot afford all these new railways, and does not need three competitive systems. We recommend, therefore, that the three undertakings, the Canadian Northern, the Grand Trunk, and the Grand Trunk Pacific be united in one system. To whom, then, should its management be entrusted?"

The commissioners answer this question by advocating the formation of the Dominion Railway Co., the proposed organization of which is later explained.

C.P.R. or Any Monopoly Not Desirable.

The suggested transfer of all the railways to the Canadian Pacific is rejected on the grounds that a railway monopoly is not desirable either in the hands of a company or in the hands of the state.

The suggested transfer of the Canadian Northern to the Canadian Pacific is rejected because it would re-establish what would be a practical monopoly in the Prairie Provinces and would leave the country to carry the burden of the G.T.P., which has little hope of prosperous development if isolated. The suggestion that the C.P.R. be invited to take over only the western portion of the C.N.R. was also rejected as being of even less advantage than if they were to take over the whole road, as it has the added disadvantage of leaving the country to carry the burden of the unprofitable eastern lines.

The possibility of forming a commercial company was discussed and the report merely states, "We have come to the conclusion that this course is not feasible under the

(Concluded on page 405.)

The Manufacture of Munitions and the Permanent Assets to Canadian Industry Resulting Therefrom

An Outline of the Manner in which the Manufacturers Have Responded to the Call for Munitions—Value of Production—Results of Standardization of Products and Skill

By COLONEL DAVID CARNEGIE
Imperial Munitions Board, Ottawa.

I SHOULD like to refer first to Canada's capacity to produce munitions; second, to the permanent assets to Canadian industry arising out of munitions work; and third, to the responsibility of engineers in developing these assets.

Canada's Capacity to Produce Munitions.—In September, 1914, when General Sir Sam Hughes undertook the first order for shrapnel shells, Canada's capacity to produce shells amounted to 340 18-pr. shrapnel shells per week. These were made at the Dominion Arsenal, Quebec. The capacity of Canadian factories to-day approximates 400,000 18-pr. shrapnel complete rounds per week, including cartridge cases, primers, fuses and propellants. In addition to this amazing output there is a weekly capacity in Canada for nearly 400,000 high explosive shells, ranging in sizes from 18-pounders to 9.2-in., making an approximate total weekly output of 800,000 shells. This large output, along with other supplies made independently, requires weekly about 25,000 tons of steel, 2,500 tons of brass, 750 tons of copper, 250 tons of zinc, 1,500 tons of lead, 200 tons of antimony, 150 tons of resin, several tons of ferro-molybdenum, and about 1,300 tons of explosives—500 tons of cordite, 500 tons of trinitrotoluol, 300 tons of nitrocellulose powder. Over 300,000 boxes are required for these shipments per week, and about 3¼ million lineal feet of board are used in making these boxes.

The Value of the Products.—The weekly value of these products can only be understood by people who have learned to think in millions.

The total value of orders for munitions placed in Canada approaches eight hundred million dollars, and the value of the munitions shipped is close upon five hundred million dollars.

The Amount and Value of the Plant Employed in Producing Munitions.—Looking again at the magnitude of munitions work in Canada to-day, we see 650 factories engaged in 144 towns scattered throughout every province of the Dominion, except Prince Edward Island. Cities as far apart as St. John, Newfoundland, and Victoria, B.C. (a distance of approximately 4,500 miles), are contributing to the output. Manufacturers from almost every industry in Canada have turned their attention to the production of munitions, and it is gratifying to record that few of them have failed in producing the standard of work required.

Gauge Production.—One can hardly mention this subject without being reminded of the almost insuperable difficulties which were presented in the early days of the war in obtaining gauges for munitions. We can never thank the United States manufacturers sufficiently for what they did in coming to our aid at that time. The special skill in making gauges to the limits of accuracy required could not then be found in Canada. To-day there are at least twenty factories producing gauges in Canada, and while we are not independent of help from the United States, some idea of the magnitude of the work can be understood from the monthly bill, which amounts to over $150,000 for new gauges.

During the month of March about 10,000 new gauges and checks were inspected. The usual accuracy called for on a gauge is .0003 3/10 thousandths of an inch, and for a check, 1/10 thousand.

An army of over 5,000 examiners are engaged upon the inspection under the direction of Colonel Edwards and his staff of officers.

Permanent Assets to Canadian Industry.—Hurrying from these few facts about the output of munitions in Canada, without even touching upon what would be a fascinating subject to you as engineers (I mean the scientific processes involved) and also leaving entirely out of consideration the gruesome purpose in actual warfare for which the munitions are required, I pass on to consider the value of this unholy business as a permanent asset to Canadian industry. I should like to divide the total value of the permanent assets, as I view them, into two parts. The first resulting from the standardization of products; the second from the standardization of skill.

The Standardization of Product.—No component part of munitions, however insignificant, has been made or accepted on the old principle of "good enough." Every part has been supplied to drawing and specification, with rigid examination, analysis and test before acceptance.

I think I am safe in saying that there is no industry in Canada which has been occupied in the manufacture of munitions but has passed through a process of refinement, which will leave it in a better condition when it returns to domestic pursuits after the war. If you review the great industries of Canada it will be difficult to find one which has not been actively contributing to the output of munitions.

Industries such as the iron and steel, the metals and metal products, refractory materials and fuels, lumber and timber, leather, textiles, paper, chemicals and other minor industries, have called into being processes and plant which could be adapted for munitions, and have also added new processes, new equipment and new skill where these were required.

In addition to the employment and adaptation of existing industries for munitions manufacture, entirely new industries have been brought into activity. The manufacture of munitions has given an abiding impetus to the mining and subsequent operations in the production of coal, iron, copper, nickel, zinc, molybdenum, antimony, aluminum and other metals.

The chemical industries have been accelerated by utilizing the waste products of the coke ovens for the manufacture of high explosives. These waste products after the war will be turned, by ingenuity and skill, into valuable domestic products.

*Abstract of an address before the Ottawa Branch, Canadian Society of Civil Engineers, April 26th, 1917.

The electro-chemical industries, such as the refining of copper, zinc and lead, have been initiated and will remain as a commercial asset. The electrothermic processes for the production of ferro alloys, such as ferro-silicon, ferro-manganese, ferro-molybdenum, aluminum, magnesium and other metals, have produced standardized products.

Standardization of Skill.—The widespread knowledge of new processes, involving the scientific study of metals, the flow of materials, and their physical, chemical and metallurgical values, has been such that one can hardly imagine it would have been possible for the universities and technical schools of Canada to have provided such instruction in the course of many years which has been crowded into as many months. Every workshop has been a school of training in standardizing its skill. Every factory in which steel is made and forged is now partly or fully equipped with the means for measuring temperatures and intelligently discovering the value of the materials with which they are working. In every workshop in the different provinces of Canada where shrapnel shells are made, the scientific treatment of steel is known. There is hardly a town of any importance in which the use of precision instruments and gauges for measuring shells and their component parts does not exist.

It is difficult to assess the value of this skill to Canadian industry, in which over 250,000 workers have become skilled in the art of such processes and the manipulation of such tools and gauges. It is more surprising still to know that nearly 12,000 women have become skilled in this work. Never in the history of the world has there been such an incentive to acquire such skill for a purpose the like of which our civilization should be ashamed, but which is nevertheless an asset which will be of great value in the peaceful commercial industries for the expansion of Canada.

Contributing Factor in the Standardization of Skill.—The mental processes which have been silently at work developing character while the hands of the workers have been acquiring precision in the use of tools and gauges, are factors in the life of the individual worker which cannot be overlooked. Canada has shown a rare capacity during this great war, comparable in some measure with the vastness of its territory.

The Responsibility of the Engineer in Developing These Permanent Assets.—Gentlemen, ours is an honorable profession, one crowded with vistas of research and delights the like of which even the angels might envy. This war has awakened the slumbering forces in the human mind and brought into activity engineering genius unequalled in quality hitherto. Your great waterfalls have been transformed by your skill into the most resourceful agency of power, without which we would have hopelessly failed in reaching the output of munitions named. Your skill has mined, smelted and fabricated the many metals which have proved to be of such value for munitions. The great engineering plants which have been brought into being by your skill are monuments of industry which must not be allowed to rust when this war is over. There is a great responsibility resting on you as engineers and leaders of industrial thought and action. It is greater to-day than ever before in the history of Canada. The opportunity given to you of taking and intelligently using and directing those assets of which I have spoken is of vital importance to Canada's successful industrial development. There is no need to wait for royal commissions. Power and authority are vested in yourselves; nothing will be too great for you if you see your opportunity, and if you have faith in the engineering talent of Canada. The man who was afraid and went and hid his talent in the earth brought forth the most scathing reproof ever uttered.

If I were to venture to suggest a programme for your immediate consideration, I would advise you to classify and value the engineering skill of your societies with the object of forming in Canada from their membership small committees of scientific, technical and commercial men, who would be responsible for obtaining from the accumulated reports of commissions and numerous supplies of information stored in government departments and elsewhere relating to the best standardized processes, equipments and plants for the development of the industry they represented. Each committee would therefore become the recognized source of classified information, to whom manufacturers could with confidence refer for any help and advice required.

If your inventory of classified ability were broad enough to include the fuller issues in developing the standard of products, skill and utilitarianism, I should utilize every willing member of your profession, making committees, say, of members not exceeding three, for the consideration and report of the following subjects:—

1. Industrial, technical and commercial education for our boys and girls before and after leaving the day school.
2. The classification and valuation of labor.
3. The remuneration and hours of labor.
4. The direction and character of employment in classified industries.
5. The provision of methods for the prevention of unwholesome competition between manufacturers.
6. The provision of definite standards for checking the formation of doubtful companies.

Then, with a central authority you could co-relate the efforts and information of your scientific and industrial committees for a broader policy of universal trade.

By the consideration of some such programme those valuable assets which are now the heritage of the Canadian people will make this country prosperous. Canada has its opportunity to set the pace in the world's industry. Its finances were never better. Last year its exports exceeded its imports by $340,000,000. Its natural resources cry out to you for their development. It is a country in which there is a heritage of wealth far exceeding that with which our youthful imaginations surrounded "Treasure Island." Your efforts in embracing those opportunities will be strengthened by a more complete education of the industrial workers, and by a heartier co-operation with the employees.

"A nation," said President Wilson, "is as great and only as great, as its rank and file." Will you, gentlemen, see that the rank and file who make this nation follow those lofty standards of education and sacrifice which make life great?

It would be terrible if we missed the way after such a struggle.

There is a great industrial war before us, for which we are unprepared.

A new north and south international highway from Winnipeg to San Antonio and Galveston and possibly to the city of Mexico and the Panama Canal by way of Kansas City is projected by a Kansas organization.

It has been announced in New York that a contract, providing for the reconstruction of important buildings in the destroyed cities of northern France, has been closed between the French Government and Kennedy, Mitchell & Company, bankers, of New York and London. Virtually all the material to be used will be purchased in the United States. The contract is for 200,000,000 francs.

THE GOVERNMENT WHITE ELEPHANT AT QUEBEC.

By C. V. Johnson, A.M.Can.Soc.C.E.

ALTHOUGH it is almost a year and a half since the so-called Transcontinental Locomotive and Car Shop plant at Quebec has been completed, insofar as it was allowed to be completed, there has as yet been no sign of activity within its doors, if we may except the occasional flying visits of high officials who come, look, and depart—to be seen no more.

What is the explanation for this seeming apathy on the part of those in authority? Like Bob Ingersoll, "we do not know." It cannot be that these buildings, handsome though they may be, were erected for the sole purpose of being pointed out to visitors as one of the sights of Quebec. At this time of industrial activity, when all the resources of the country are "supposed" to be organized for the purpose of assisting the Empire, would they not appear much more in keeping with the part our Dominion is expected to play if they were in full activity of producing some of the materials of which there is so great a need? Munitions, guns, locomotives, cars, or any of the thousand and one articles which go to supply the needs of those who are so nobly risking their lives for the sake of humanity.

Many reasonable suggestions have been put forward as to the use to which the plant might be put, and companies have even been formed with a view to securing the use of the buildings from the government for the manufacture of munitions, only to be met with the vague statement that the shops are not available at the present time. It would appear, however, that there is no necessity even to change the nature of this plant to make it serve its purpose, as it could be very well employed in turning out cars and repairing locomotives, for both of which there is a crying need on all sides.

It is very well known that the transportation problem has become serious of late; so much so, in fact, that embargo after embargo has been placed on shipments of all kinds. In order to relieve the car shortage, the demurrage charges have been boosted to a previously unheard-of figure.

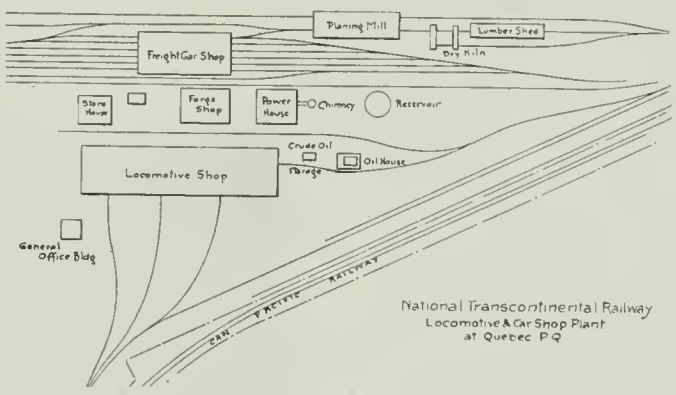


Fig. 1—Plan of N.T.R. Plant at Quebec.

The explanation of this appears to lie in the fact that while shipping has been vastly increased since the beginning of the war, the usual supply of rolling stock has appreciably decreased—due no doubt to the increased profits to be made from the manufacture of shells as against cars and locomotives. In all reason there must be an end to this sometime, else when the shortage becomes more acute—which will be in the very near future—how are the materials for munitions, the shells, and the necessities of life, to be moved from the points of supply to the ultimate consumer? Does it not seem reasonable to suppose that a resumption must be made at some time in the construction of cars, and why not now before the need becomes so great that it will seriously disorganize interior arrangements? Here, then, is a plant ready to hand, one million and a half of dollars in buildings alone, excellently situated, and requiring only the installation of machinery to make it ready to play the part for which it was originally designed, and for which it is at the present time much more needed.

In order, then, to give engineers an idea of the magnitude of this plant, a general description will be given, together with the details of the various buildings as constructed.

The Site.—The shops are situated on the western outskirts of the city of Quebec, in St. Malo Ward, not more than five minutes' walk from the end of the street car line, and immediately adjoining the C.P.R. tracks at Biggar siding. The ground at this point was formerly considered a swamp, and was frequently objected to as a site on this score, but owing to the complete system of drainage which has been installed, and the many thousands of cars of sand filling which have been spread over it, it is now well-graded and dry.

As a matter of fact, the ground never was of such a nature as to deserve the name of swamp, but was, owing to its flat nature and lack of natural drainage, the receptacle for the run-off from the hill to the south. The nature of the ground itself proved ideal for the construction of the buildings, as the rock, commonly known as Quebec shale, was encountered generally within a few feet of the surface, giving an excellent bearing for the foundations. On the other hand, this shale was a considerable handicap in excavating for drainage and water

Fig. 2—General View of Shops a Month Prior to Completion.

lines, but the extra expense incurred on this account was more than compensated for by the saving in the depth of foundations for the buildings.

The Plant.—The buildings themselves (twelve in all) are generally of brick and steel construction on concrete

Fig. 3—Interior of Locomotive Shop.

foundations, with double wooden-sheathed roof covered with Brantford No 3 prepared asphalt roofing. The windows are Fenestra steel sash throughout, glazed with ribbed glass; and the skylights, Douglas Bros. metal ribbed with a double thickness of 3/8-in. and 1/4-in. ribbed wire glass. The doors are of wood, in general 3 ins. thick, with steel frames, the large engine doors being fitted also with pass doors. The floors were intended to be of concrete, with a 1-in. and 1½-in. mastic finish, but as no machinery foundations have as yet been put in it was decided to leave the floors undone so that they would not have to be torn up at some future date for the installation of machinery.

All the buildings, with the exception of the locomotive shop, are equipped with the Miller vacuum direct steam radiation heating system, the steam to be supplied direct from the power house. The locomotive shop is equipped with an indirect heating system consisting of

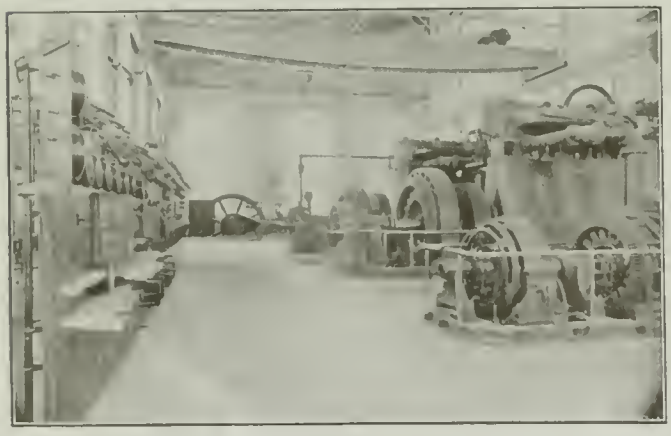


Fig. 4—Power House Engine Room.

two Sirocco fans, from which the hot air is driven through concrete ducts underground to all parts of the building.

The water system is complete throughout the plant, the supply being obtained in 10-in. mains from the city of Quebec water mains, under a normal pressure of about 100 lbs. and distributed through all the necessary branch lines to all parts of the yard and shops. An emergency system is also installed in such a manner that, in case of accident, the water may be pumped from the reservoir which forms a part of the plant. A complete system of fire hydrants has been installed both in the buildings and through the yard, as also two 6-in. standpipes for supplying the locomotives.

The drainage system is double, the roof and surface run-off being carried direct to the St. Charles River on Lesage Avenue, and the sewage being emptied into the city sewers. The yard itself is very extensive, being capable of storing an almost unlimited amount of material, besides allowing for shop expansion to many times the present dimensions.

The original plan contained some twelve miles of trackage, of which about seven miles have been laid and ballasted, these being directly connected with both the C.P.R. and Canadian government lines. A scheme was at one time broached and plans actually prepared for a double track tunnel extending from the Transcontinental line at Wolfe's Cove on the St. Lawrence River to connect with the shops; but this was later abandoned and the Canadian Northern line from the Quebec Bridge taken over instead, this giving a connecting link some six miles in length with the Transcontinental main line.

Fig. 5—Interior of Freight Car Shops.

In the construction of the shops about 135,000 cu. yds. of material was excavated, and there were employed some 3,000 tons of structural steel, 23,000 cu. yds. of concrete, 3,000,000 bricks, 850,000 ft. B.M. of lumber, 56,000 sq. ft. of window sash, 60,000 sq. ft. of skylights, and 166,000 sq. ft. of roofing material, besides 150,000 cu. yds. of filling and ballasting material for the yard.

Locomotive Shop.—This building, the largest in the plant, comprising a locomotive erecting and machine shop, and a boiler and tank erecting and machine shop, is approximately 600 ft. long by 150 ft. wide, and contains eighteen engine pits with tracks, and four overhead electrically driven travelling cranes. The cranes are of the following dimensions and capacities: Two 10-ton, respectively 20 and 50-ft. spans; one 20-ton with 68-ft. span, and one 120-ton with 74-ft. span. There is a balcony 20 ft. in width extending the full length of one side of the building, and containing the fans, lavatories, foremen's offices, etc. Three standard gauge tracks are laid in the shop and connected with the tracks in the yard. An interior view of a portion of this shop is shown in the accompanying illustration, Fig. 3.

Forge Shop.—This shop is 107 ft. wide by 155 ft. long, and is at the present time entirely empty of any equipment, with the exception of the heating and water systems.

Storehouse.—The storehouse is 78 ft. 6 ins. wide and 103 ft. 6 ins. long, consisting of a reinforced concrete floor some four feet above the ground level, together with a reinforced concrete platform outside, 10 ft. wide and extending around three sides of the building. It is also supplied with heating and water systems, and has provision for a scale which is not as yet installed.

Oil House.—This building, 50 ft. square, is constructed somewhat differently from the others, consisting of a concrete floor, 8 ft. below ground level, on which the tanks are placed, concrete walls, and an upper floor of reinforced concrete on which the pumphouse, 30 ft. by 40 ft., is situated. There are installed in the building nine tanks, seven of 3,300 gals. capacity, and two of 6,000 gals. capacity, and in addition there is a gasoline storage tank of 1,800 gals. capacity buried in the ground just outside the building, and connected with it by the necessary piping. The whole oil system is completely equipped with Bowser measuring pumps, fill boxes in the platforms with nozzles and locked valves for gravity fill from cars, manholes, indicators, drains, etc.

Crude Oil Storage.—This little building is 42 ft. 8 ins. long by 21 ft. wide, constructed entirely of reinforced con-

Fig. 6—View from Roof of Office Building, showing Engine Pits in Locomotive Shop and Steel Framework of Forge and Power House.

crete below the level of the ground, and containing four tanks each 7 ft. in diameter and 15 ft. long.

Power House.—The power house is 124 ft. 6 ins. long by 107 ft. wide, consisting of two compartments separated by a brick wall, one containing the boilers and the other the machinery. The equipment is practically complete at the present time, successful tests having recently been carried out by employees of the Canadian Government Railways and representatives of the manufacturers.

The engine room contains two 500-kw. and one 175-kw. steam-driven generators; two 150-kw. and one 75-kw. motor generators; one 1,500 cu. ft. air compressor; one switchboard; two pumps; feed water heater, and all the necessary connections. In the other side are situated five 500-h.p. boilers, supplied and installed by the Goldie-McCulloch Co. Fig. 4 shows an interior view of the engine room.

Forge Stores.—This is a wooden framed building covered with asbestos shingles, and fitted with an iron storage room containing iron racks, and a coke and coal storage room, together with a scrap platform with removable partitions.

Freight Car Shop.—This shop is 130 ft. wide by 285 ft. long, containing one 25-ton travelling crane with a 78-ft. span, and one 10-ton with a 20-ft. span. There are

Fig. 7—Power House.

six standard gauge tracks running the full length of the building, and connected at both ends with the yard tracks. The building is also furnished with complete heating and water systems. Fig. 5 illustrates the interior of the shop.

Planing Mill.—This is 82 ft. wide by 265 ft. long, with exhauster room on the north side, and contains two standard gauge tracks, also connected with the yard system. Heating and water systems are completely installed.

Dry Kiln.—This building is 38 ft. 4 ins. wide by 71 ft. 6 ins. long, and is constructed of brick on concrete foundations, with terra cotta lined walls, terra cotta partition in the centre, and suspended ceiling of metal lath and plaster. The heating system, which is complete, consists of approximately 1,800 sq. ft. of radiating surface, control cabinets, valves, gauges, fittings, etc. There are contained in the building four narrow gauge tracks, and at each end transfer pits on the outside of the platforms.

Lumber Shed.—The lumber shed is 40 ft. 6 ins. wide and 225 ft. 6 ins. long, wooden framed on concrete piers,

Fig. 8—Constructing Manholes with 30″ Concrete Pipe.

with wood-sheathed walls covered with asbestos shingles. It is floored with 3-in. plank laid on sleepers in a gravel fill, and has one standard gauge track through the entire length.

Office Building.—The office is 60 ft. square, consisting of three stories and a basement, and contains ample space for any staff likely to be employed in the management of the plant. The interior contains offices, draughting rooms, printing rooms, vaults, etc., and is finished throughout in hardwood, with plastered walls and ceilings, and maple flooring. The basement has a concrete floor surfaced with mastic flooring. This building is also heated with the direct radiation heating system from the power house, and is completely furnished with electric lighting, telephone wiring and bells.

Reservoir.—The reservoir is of mass concrete construction, having an inside diameter of 60 ft. and a depth of 15 ft., the capacity being 300,000 gallons. The supply pipe, 10 ins. diameter, is fitted with a float automatic control valve, besides an auxiliary valve located in the adjoining valve house. The reservoir is connected with the pumps in the power house by means of a 12-in. diameter pipe, this pipe being also connected with the main supply by means of a by-pass. All supply, suction, overflow and drain pipes are in place, together with a complete valve-operating equipment.

Midway Crane.—Between the locomotive shop on the north side, and the storehouse, forge shop and power house, is situated the midway crane runway approximately 650 ft. long, with an electrically driven travelling crane of 15 tons capacity and 75 ft. span.

Chimney.—The chimney is of reinforced concrete, 200 ft. high, and 9 ft. inside diameter at the summit. See *The Canadian Engineer* of March 16th, 1916, for article descriptive of this chimney.

Pipe Tunnel.—In addition to the plant described above, there is also constructed a yard pipe tunnel ready to receive the piping from the power house to the various buildings. This piping is not yet in place.

Construction.—The contract for the construction of these shops enjoyed the distinction of being one of the few on the Transcontinental Railway to be completed within the stipulated time. Work was commenced on September 15th, 1913, and carried on continuously winter and summer until the completion, about December 1st, 1915, one month prior to the expiration of the contract time.

During the late fall of 1913, excavation work was done for the locomotive shop, forge shop, storehouse and power house; and during the month of January, 1914, for the freight car shop, planing mill, reservoir, and office building. Concrete work was carried on until the end of December, and again resumed early in March.

During the winter of 1913 and 1914, work was very scarce in Quebec City, resulting in a great deal of unemployment, and the contractor was approached with a view to having him carry on as much of the construction as possible in the winter months. To this end he agreed to do all the excavation for the sewer and water lines, and thus employed about six hundred men all through the slack months of the winter. Excavation was naturally rather difficult owing to the severity of the winter, the great depth of frost, and large snowfall, necessitating much blasting of frozen material and a great amount of snow shovelling. The trenches for the pipe lines varied from a depth of six feet at the upper ends to twenty-two feet at the lower. Large quantities of shale and boulders were encountered, and much difficulty was experienced in keeping the trenches clear of water. Towards spring, when the strength of the sun began to be felt, such trenches as were not backfilled had to be well shored, as the Quebec shale quickly disintegrates when exposed to the sun and air, giving rise to continued slides if not held up. Nevertheless, the whole of this work was completed about the middle of March, 1914, and the working force then concentrated on the foundations for the various buildings.

During the summer of 1914 all concrete foundation work, structural steel work, and a large part of the brickwork was completed, some five to six hundred men being employed on the construction. In the winter of 1914 and 1915, the remainder of the brickwork was erected, also the oil house and chimney. That winter the whole of the excavation and concrete work was done for the yard pipe tunnel of reinforced concrete (a description of which work has already been published in the issue of *The Canadian Engineer* for February 24th, 1916).

This left the contractor free to do the finishing work and "cleaning up," and to concentrate on the yard filling, tracklaying, and ballasting, during the summer of 1915. The filling material was taken from the Montmorency pit of the C.N.R., a distance of about twelve miles from the shops, and hauled in Hart side-dump cars, unloaded with a Lidgerwood, and spread with a Jordan. In all about 5,000 cars of material were used in this work, the whole being accomplished in about two months time, although it was well into September before the tracks were completely lined up and ballasted.

The general contract was carried out by the firm of Joseph Gosselin, general contractors, Quebec and Levis, under the superintendence of Joseph Gosselin, Jr. The sub-trades were carried out by the following firms:—

Structural steel, Eastern Canada Steel & Iron Works, Quebec; window sash and skylights, L. H. Gaudry & Co., Quebec; plumbing, electric wiring, and indirect heating apparatus, Fortunat Gingras, Quebec; direct radiation heating system, F. W. Miller Heating Co., Chicago; roofing and sheet metal work, Eugene Falardeau, Quebec; painting and glazing, Ovide Lachance, Levis. The cast-iron piping was supplied by Drummond & McCall, Montreal; the steel sash, by Steel & Radiation Co., Toronto; the skylights, by Douglas Bros., Montreal; the paint, by Canada Paint Co., Toronto.

The plans for the buildings were made under the direction of H. Laberge, architect for the Transcontinental Railway, who also acted as chief inspector during construction. E. B. Forrest was engineer in charge for the N.T.R., and H. E. Balfour, assistant engineer. We are indebted to Mr. Balfour for the photographs illustrating this article.

The American production of ferro-manganese last year amounted to 208,389 gross tons, or double the normal output. In the supplies of manganese ore still more striking records have been obtained. The imports probably exceeded 560,000 tons, almost entirely from Brazil, larger, for the first time, than the imports of Great Britain.

The United States Consul at Dairen reported recently that there has been constructed at the South Manchurian Railway workshops three locomotives for the French railways in Cochin-China. The locomotives weighed 64,103 lb., and with the tender 103,053 lb. The same authority also says that the Japanese Railway Board will, in future, construct its own electric locomotives, for use on the Usui line, instead of obtaining them from Germany.

Search for graphite deposits in the United States since the war started has brought to light the largest known deposit of high grade mineral on the continent, says the New York State Department of Labor. It is between Lake George and Lake Champlain in the vicinity of Black Mountain. The veins crop out for nearly a mile with a thickness of 50 ft. The graphite content indicates a variation of 6 to 10 per cent. of the large flake variety desired by crucible makers while a 6 ft. layer assays over 15 per cent. of high grade graphite.

EFFORTS BEING MADE TO APPOINT STREAMS COMMISSION FOR ONTARIO.

ON March 29th, at Galt, Ont., a conference was held at which was strongly advocated the appointment of a provincial commission to study control of the rivers of the province. Delegates were present from Preston, Hespeler, Kitchener, Paris, Brantford and other municipalities in that section of the province.

As chairman of the Grand River Improvement Association, Mr. W. H. Breithaupt, M.Can.Soc.C.E., spoke of the work done by that association in its efforts to get improvements on the Grand River, and pointed out how the land now damaged by these floods is becoming more valuable each year, and showed how urgent it was that some steps be taken by the government to adopt some methods by which the floods could be controlled.

In the course of his remarks he referred to what was being done in various countries to cope with the problem of river control. He said, in part:—

"Let us take a brief survey of what is being done in the United States. On the Allegheny and Monongahela Rivers, which together form the Ohio River, seventeen flood prevention reservoirs in Pennsylvania, Maryland and West Virginia at a cost of $20,000,000 are now definitely projected.

"In Kansas, the State Flood Commission has reported that losses by floods during the past thirteen years have amounted to $20,066,000 in that State, an average of $4,000,000 annually, and have cost 100 lives.

"There are river commissions in a number of States across the line, and very extensive programs are constantly being elaborated and carried out.

"It is not that floods are continuing to increase very much. On the Grand River, for instance, the largest observed flood was five years ago, and it is not likely that conditions tending to large floods will become much more accentuated in our drainage basin. A great and growing need for regulation is that property subject to destruction is so greatly increasing in values. Prevention of annual damage should keep pace with such increase in values. There are important reasons besides flood control for study and general administration of matters pertaining to streams. One of them is the prevention of pollution. A river is in general the discharge canal for sewage and all manufacturing wastes, to purify which before they are thrown into the river is always a greater or less cost.

"Pollution of a stream, however, is a public detriment, and must, therefore, be prevented. Water supply for the cities and towns along the valley of a river is another great question.

"In our local area this is already becoming a difficult question in a number of municipalities, notably in the city of Kitchener. The maintenance of a good flow in the streams during periods of low water is a matter of many-sided interest. In the first place, there is the increase in value of water powers on the streams. The increased flow is in itself a large benefit in a cleaner river bed and general addition to beauty and attractiveness of the entire drainage area.

"**Commission in Quebec.**—In the Province of Quebec there has been a Streams Commission since 1912. Streams problems in Quebec are in general somewhat different from those in our province. Investigations are largely for water power, but they are also for flood control and the many other general purposes of water conservation. The Commission in Quebec spends now about $50,000 a year, and maintains a permanent staff of investigators, who in cases go far beyond actually settled territory of the province.

"**Is Urgent in Ontario.**—The need for a Commission in the Province of Ontario has been urgent for many years, and there is no question that at least a beginning should be made at once. The Commission should cover the field of the whole province, and preferably consist of members from the various main drainage areas."

As a result of the conference a deputation, consisting of Messrs. W. H. Breithaupt, J. M. Patterson, Alfred Taylor and the mayors of Preston, Hespeler, Kitchener, Paris, Brantford, Caledonia and Galt, was appointed to wait on the Ontario Government and urge the advisability of at once appointing a commission to investigate flood conditions throughout the province.

REPORT ON MONTREAL PAVING WORK.

Reviewing the whole paving situation in Montreal, a comprehensive report has been submitted to Paul E. Mercier, city engineer of Montreal, by the Milton-Hersey Co., Limited, who have the contract for the chemical and inspection work in connection with the city's paving. Among the subjects covered are Material Contracts, Asphalt Cement, Inorganic Filler, Sand, Stone, Chips, Excavating and Grading, Concrete Foundations, Binder Course, Asphalt Mixtures, Hauling of Mixtures, Pavement Surface, Asphalt Plants and Accounting Control.

The report recommends that the old granite blocks be redressed and relaid and that one or more central plants be established for recutting these blocks. It is suggested that sand be purchased in at least three grades rather than in one grade, and that suitable storage bins be constructed with belt conveyers, etc., so that sands can be mixed to approximate the ideal grading.

It is stated that the asphalt cement should be of at least three degrees of consistency as determined by the penetrometer,—one for mixtures used on light traffic streets, another for medium traffic streets and the third for heavy traffic.

Complaint is made regarding the price and supply of inorganic filler, and it is recommended that serious consideration be given to the installation of a drying and powdering plant to produce clay filler which could be used in conjunction with very fine sand. The sand situation is said to be fairly satisfactory as regards price, the contractor securing but 19c. per ton to cover pay roll, equipment charge, supervision, royalty and profit. It is complained, however, that the railway freight of 70c. a ton from sand pits to the city is too high and that application should be made for its reduction.

The price of stone-chips has been very high, says the report, and it is desirable that chips be secured at a municipal quarry if lower prices cannot be obtained. It is suggested that it might be advisable to place a small crusher in each asphalt plant, to crush the larger sizes of stone, in case a municipal quarry is not opened. Attention is called to the lack of economy in having extensive auto trucks stand for long periods while waiting to be loaded during the grading operations, unless the haul is so long as to overcome the loss of time.

Better selection of the sizes of sand and stone, so as to reduce the voids in the aggregate, is recommended in connection with the concrete foundations, and more uni-

formity in the thickness of the concrete foundations and the method of finishing. It is stated that the surface of a foundation laid for an asphalt pavement should preferably be slightly roughened, resembling as much as possible the stuccoed wall of a house, whereas some of the city gangs have been noticed to trowel the surface with the backs of their shovels, while other gangs have left it entirely rough. The variation allowed should not be greater than one-half inch from the given line, as in the case of subgrade. Grade stakes should in no case be left in the concrete, as they are apt to cause damage to the surface later on. Greater care should be taken in the setting of manholes and manhole boxes, so as to render unnecessary any adjustment of the pavement surface to meet the obstructions.

It is advocated that the binder course be dispensed with and that the asphalt be laid from curb to curb or from curb to rail on streets with car tracks. It is recommended that there be only three city asphalt plants instead of four, but that they be better situated and with a much larger capacity, equipped with tanks, steam coils, automatic scales, etc.

Attention is called to the lack of cost-control systems in the city paving work, and it is recommended that the city should adopt one of the systems already built up by some experienced paving contractor.

A comprehensive scheme of paving for the city is urged, with particular attention to a system of main arteries, so that any section of the city may be reached by these main arteries, which should be well paved and maintained in the best condition, other pavements over which there is only local traffic being neglected if necessary in order to secure the best conditions on the main traffic highways.

The report contains approximately fifteen thousand words and is very exhaustive, reviewing the whole field and offering a considerable number of valuable constructive criticisms, although there are some recommendations with which all engineers would not agree, particularly the recommendation that one type of pavement be adopted as the standard throughout the whole city, the statement that certain pavements previously laid in Montreal could not have proven economical "had they lasted forever without repair or renewal," and the recommendations regarding omission of the binder course.

There are over 2,000,000 miles of so-called roads or highways in the United States, but there are only about 30,000 miles that can be described as "improved." Ten thousand miles of the 30,000 are not traversable after a heavy rain.

In 1910, California voters approved an $18,000,000 road bond issue with which was constructed a large mileage of concrete roads. The newly constructed roads proved so satisfactory that at the close of 1916 the state approved a new $15,000,000 bond issue by vote of almost 4 to 1. In 1910, Los Angeles county voters were almost 4 to 1 against the proposition, but in 1916 they turned the tables and approved the new issue by a vote of more than 3 to 1.

The forty-first annual meeting of Willans & Robinson, Limited, was held at Rugby, England, on April 24th, 1917. The balance sheet showed a trading profit for the year of $150,600. The net profit was $100,450, after payment of debenture interest, provision for depreciation of plant and machinery, re-valuation of stocks, allowances to employees on active service, and special provision for the exceptional wear and tear and outlays arising from conditions connected with war output. The reserve account now stands at $255,020, and the total assets of the firm amount to $2,923,250.

CONSTRUCTION OF BROKEN-STONE ROADS.

By George Reakes, C.E.,
Engineer and Contractor, Beaconsfield, P.Q.

IN the early part of the 19th century two systems were introduced into England for highway purposes; the first by Telford and the second by Macadam, and from these systems the modern road engineer has drawn the principles upon which all present-day broken stone roads are made.

In the making of the waterbound macadam road, sufficient attention is not paid to the natural soil bed upon which the foundation is laid. The base should be thoroughly drained, rolled till hard and compact, and to the same grade and shape as the finished road. On this the foundation is laid either on the Telford or Macadam system, the Telford foundation consisting of large stone laid by hand in the form of a close and firm foundation, set upon their broadest edges, lengthwise across the road.

The principal defects of this foundation are the large percentage of voids left between the foundation stone, giving free access to water, and thus defeating one of the main objects of the road covering, and its high cost of construction.

The writer, in building a stretch of road a mile long, used the Telford method of hand-placed stone, and in order to reduce the percentage of voids as low as possible, spread a layer of clean stone screenings over the foundation, well-watered, broomed in and well rolled. (Owing to the close proximity of the quarry, the cost of road was greatly reduced.)

For the Macadam method, 1½-inch stone is laid to a depth of 10 or 12 inches, no binding material being used, the stone being left to work in and unite by its own angles under the traffic. The writer, in making a 3-mile stretch of macadam waterbound road, used for foundation stone broken to about 5 inches in size and laid in two layers, each layer well watered and rolled, a layer of stone screenings spread over same, well watered and broomed in to fill up all voids.

The second course of stone was 2½ inches in size and treated with water, rolling and screenings. The wearing course was of 1-inch stone, about 3 inches in depth, rolled, watered and stone screenings spread on. After the final rolling, stone screenings were again spread on and left for 14 days, when roller and water cart were again called into requisition and the whole length watered and rolled again, all surplus material being swept off.

The essentials in making successful broken-stone roads are:—

(*a*) The removal of the natural soil to such a depth as may be necessary, according to the soil and thickness of the intended covering.

(*b*) Thorough sub-surface drainage.

(*c*) The use of best materials, reduction of voids and complete exclusion of clay loam from the broken stone.

(*d*) The use of clean, sharp sand, gravel or stone screenings.

(*e*) Work to be carried out under proper engineering organization and in a systematic manner.

The question of maintenance of these roads after being built should be taken into consideration. Many municipalities making good roads seem to ignore the fact that roads, like everything else, will wear out. They are often left to take care of themselves, and this results in a heavier cost in the end for repairs.

RAILWAY ENQUIRY COMMISSION'S REPORT.

(Continued from page 396.)

circumstances as they at present exist," without outlining any of the reasoning leading up to that conclusion.

The Mexican precedent, whereby the government indirectly controls the roads through stock ownership, and the New York Subway precedent, where the government owns the roads and leases them upon terms ensuring the lessor a return on his investment, were also rejected.

Outline of Dominion Railway Co.— Its Organization and Prospects

The majority report recommends that the Dominion Railway Co. have a nominal capital of $50,000 divided into five hundred shares, each trustee holding a hundred shares registered in the joint names of each trustee and the minister of finance. The trustee, having been named first, would be entitled to the vote, but could not transfer his shares without the finance minister's signature, and the charter would provide that no share could be transferred except to a duly appointed trustee, and that the shares were to be held in trust for the Dominion.

It is recommended that the government should transfer to the trustees the $40,000,000 common stock of the C.N.R., and all the Intercolonial and N.T.R. assets; that the C.N.R. transfer the $60,000,000 stock remaining into private hands; and that the G.T.R. transfer the whole of their stock and also the whole of the common stock of the G.T.P., the latter to be without payment except for the actual cash paid for shares other than those held by the G.T.R.

The C.N.R. common stock shareholders are to be paid an annuity decided by arbitration. The G.T.R. shareholders are to be paid annually a moderate but substantial (arbitrated) percentage of the $3,600,000 dividends which they have been receiving for the last ten years. The board of trustees is to be appointed by parliament in the original instance and to consist of three experienced railway men, one financial or business man and one labor leader. The first three railway trustees are to retire respectively after three, five and seven years' service, the other trustees respectively after four and six years.

To Keep Party Politics Out of Management.

The term of office of each trustee, with the exception of the first appointments, will be seven years, and the board will thus be permanent and self-perpetuating. Upon the retirement of a trustee, his four colleagues are to name his successor, but their choice must be approved by the governor-in-council. Failing such approval, a new name must be submitted by the trustees. All trustees are eligible for re-election but must retire at the age of seventy years. In case of death or disability of any trustee, his successor is to be elected merely for the unexpired term of office.

Only the three railway trustees are expected to devote their entire time to the company. The trustees have the power to appoint vice-presidents in charge of operation and other branches of management. It is advised that the trustees should be given wide powers in determining upon centralization or local management and in regard to the combination of the systems and elimination of waste. The board is preferably to be non-political, but in case men of recognized political affiliation are chosen, it is inferred that not more than three of the trustees should be from either of the two parties.

The board of trustees is to be independent of parliament, and to manage the Dominion Railway Co. with the object of earning dividends on the entire capital cost on all the roads under their control. The government is to assume responsibility to the trustees for the interest on all securities of the new combined system.

From the table on page 389 it will be seen that there is a deficiency of about $10,500,000 on operation, during the past year, of all the roads forming the Dominion Railway Co. To this must be added the cost of settlement with the convertible income debenture holders of the Canadian Northern, the annuities payable to Grand Trunk and C.N.R. shareholders, and the interest on the capital necessary to complete the system and make urgently needed betterments and additions. Further, the commissioners do not consider that the Grand Trunk dividend is a really net surplus but that it ought to go back into the maintenance of the property. On the other hand, they say, the economies resulting from the amalgamation ought to be very large.

The commissioners take as a starting point a total deficiency of about $12,500,000 a year. They feel that it is not unreasonably sanguine to hope that this deficiency can be eliminated in the course of six or seven years. A few specimen economies resulting from combination are given. As one instance, it is said that by building thirty-five miles of new road, the Dominion Railway Co. would have a shorter Winnipeg-Toronto mileage than any of the existing roads, shorter even than the C.P.R.

Valuation of C.N.R. and G.T.P. Establishes New Record for Cost

A physical appraisal of the C.N.R. and G.T.R. was conducted under the direction of Prof. Geo. F. Swain, of Boston. A new record was made in this valuation work. No less than 13,425 miles of railway were valuated in six winter months, October to March, and at a cost of only about $3 a mile. The cost of this valuation compares with $240 per mile for the Interstate Commerce Commission's valuation of United States railroads, with $40 per mile for Prof. Swain's valuation of the New York Central Lines, and with $50 to $100 per mile for other valuations which have been made by him.

Besides 9,375 miles of C.N.R. and 2,698 miles of G.T.P. main line and branches, there were valuated 1,352 miles of C.P.R. for purposes of comparison.

Prof. Swain's engineering assistants were W. H. Chadbourn, chief engineer; C. S. Gzowski, in charge of examination of certain C.N.R. and G.T.P. lines, assisted by G. H. Burnett, J. W. Chappelle and L. Phillips; G. R. Balloch, in charge of examination of certain C.N.R. lines, assisted by H. MacNeil, F. O'Gara, L. J. M. Howard, and J. Rainboth; A. H. N. Bruce, in charge of examination of certain C.N.R. branches; T. S. Armstrong, in charge of examination of certain C.N.R. lines; W. H. McGaan, in charge of examination of certain C.N.R. lines, assisted by W. B. Elder; N. Cauchon, specially assigned to valuation of real estate at terminals; H. Horner, architect, in charge of valuation of buildings of all kinds; B. M. Hill, in charge of examination of G.T.P. between Winnipeg and Edmonton; A. L. Ford, in charge of preparation of report on G.T.P. between Edmonton and Prince Rupert; C. Gilmore, assisting Messrs. Hill and Ford; E. C. Keefer, general office assistant, engaged in working up the final reports, making estimates from profiles, etc.; C. H. Larkin, engaged in estimate of areas and values of right of way.

HIGH VOLTAGE TRANSMISSION LINE TO SPAN ST. LAWRENCE RIVER.

By Frederick T. Kaelin, E.E.,
Assistant Chief Engineer, Shawinigan W. and P. Co.

THE Shawinigan Water and Power Co., which furnishes electric power to all of the large industrial centres of Quebec Province, in order to transmit properly the increased amounts of power to its receiving stations located south of the St. Lawrence River, has found it necessary to undertake an engineering feat of considerable interest.

Designs are being prepared for the construction of a 5,000-ft. clear span of the St. Lawrence River for the conductors of the electric transmission lines, thus supplementing the existing submarine cable installation already supplying power to the mining and manufacturing districts. This span is the longest known of its kind, and will be located about 1¼ miles upstream from Three Rivers, P.Q.

The three electrical conductors will be made of the highest grade of plough steel, spaced fifty feet apart, all in the same horizontal plane, arranged thus to prevent contact with each other due to swinging. In order to connect with existing transmission lines, the crossing conductors will be insulated from the steel towers and earth against a difference of electric potential of 100,000 volts. Because of the very high tensile stresses in the cables they will not be anchored at the towers, but will be supported on the top of the towers by saddles, permitting the movement due to temperature changes, and be anchored to concrete blocks some distance behind each tower.

The mechanical problems of this arrangement of anchoring permit of easier solution than do the problems of the electrical insulation of the conductors from the earth potential of the anchorage. The magnitude of the ceramic and mechanical engineering involved in the electrical insulating problem can better be appreciated when it is pointed out that in addition to the electrical stress incident to the 100,000 volt transmission potential the insulation for each conductor must provide sufficient mechanical strength of above 100,000 pounds in compression, due to the tension of the cable. Further, the arrangement of the insulation must permit the replacement of any portions showing electrical failure without incurring hazard to the mechanical safety of the span. An elaborate arrangement of porcelain insulators of a new type, held in compression only, has been designed to fulfil the conditions specified.

The structural steel towers, one on each side of the river, weighing approximately 200 tons each, are to be built upon concrete piers located in the river, 500 ft. from each shore. These towers rise to a height of 350 ft., which is the same height as the top of the Quebec Bridge. This great height is necessary in order to provide 160 ft. clearance above the water level under maximum conditions of ice-loading of the conductors. As the river is navigable for the largest ocean vessel, this clearance must be provided.

The river bottom is composed of sand to extreme depths at this point, so the concrete footings are of considerable interest. The footing piers will be excavated by the use of concrete caissons, which, when sunk to full depth, will be filled with concrete, remaining as a part of these piers. The piers are cylindrical in section, 11 ft. in diameter, extend to a depth of 40 ft. into the river bottom, and 25 ft. above the bottom, being partially submerged. At the top, above the water level, the piers are tied together by concrete struts, forming a square, 60 ft. by 60 ft.

It is expected that the work on this long-span river crossing will start as soon as the St. Lawrence River conditions will permit. It is planned to complete the whole work in the year 1917.

SURVEY OF CANADA'S RESOURCES.

The Advisory Council for Scientific and Industrial Research is making a broad survey of the possibilities of the Dominion in the way of scientific research and other work with the available laboratories, technically trained men and other facilities, with a view to mobilizing these forces for the speedy and satisfactory solution of the many problems facing the Dominion in the readjustment of business after the war. A series of questionnaires is being sent out, chiefly to the universities, to professional men, and to the managers and directors of the Canadian industries.

The Canadian Mining Institute, the Canadian Society of Civil Engineers and the Canadian Society of Chemical Industry are co-operating with the Council in conducting this work.

A central committee has been appointed at Montreal, with branches in the various provinces, to look after the work of taking the census in such a manner as to learn the research requirements and future needs of the Canadian industries, with a view to providing for their requirements in such manner that in years to come they will not be dependent for supplies upon Germany, for instance, as in the past.

H. Mortimer Lambe is chairman of the central committee, supported by Prof. Ernest Browne, for the Canadian Society of Civil Engineers; Mr. G. M. Murray, for the Canadian Manufacturers' Association; Dr. Milton Hersey, for the Society of Chemical Industry, and H. H. Couzens, representing the Joint Committee of Technical Organizations, Ontario branch.

The provincial organizations have divided their work into districts, under local captains, so as to ensure a thorough distribution of the questionnaires.

As replies are received, they will be sent to the secretary of the Advisory Council at Ottawa, where the information gained will be considered and collated. The work is being done under the advisement of Sir George Foster, minister of trade and commerce, and under his direction further developments will depend upon the information gained.

INTERNATIONAL JOINT COMMISSION MEETINGS.

The International Joint Commission met in Toronto last week for four days. There was a full attendance, all three United States members being present, and all three Canadian members, together with both secretaries and both consulting engineers. The finishing touches were put to the Commission's report on the levels of the Lake of the Woods, and the document is now believed to be ready to be submitted to the Canadian and United States governments. It is said to be in seven volumes, three containing engineers' reports and maps, the others including the evidence and recommendations.

Editorial

MECHANICAL HANDLING OF ASPHALT.

Under the above title an article appeared in the August 3rd, 1916, issue of *The Canadian Engineer*, descriptive of a tank erected in Toronto by the Commissioner of Works, to enable the city to handle asphalt in bulk instead of in packages. The operation of this tank has been so successful, and has so materially reduced the cost of asphalt to the city of Toronto, that the subject will prove of interest to all municipal engineers who purchase any quantity of asphalt.

The Toronto tank cost, with steam coils, $1,270; the cost of the pump was $337, and the cost of the pipe lines, steam jacket and foundation for tank was $400. The total cost, therefore, was only approximately $2,000, but prices of steel structures have increased considerably since the contract for this tank was awarded, and another similar tank would no doubt cost more to-day. The Toronto tank can handle one hundred tons of asphalt at a time, which is approximately three tank-carloads.

The Department of Works of Toronto is required each year to keep in repair an increasing area of asphalt and other bituminous pavements, and in addition lays a certain number of new pavements by day labor in addition to those laid by contractors. To carry on this work approximately 2,000 tons of asphalt are used each year.

Upon the basis of 2,000 tons, all received in tank cars, a direct saving of from $5,000 to $6,000 is effected, as there is usually a differential in price between tank and package shipments of from $2.50 to $3.00 per ton in normal times. At present cost of metal packages, the differential is even higher. The average differential on all bids received by the city of Toronto for the past three years is $2.68.

To this initial saving should be added the saving in labor of stripping and of unloading and handling of packages. The saving in stripping is particularly noticeable in hot weather, when it is difficult to strip barrels.

With modern equipment, such as pumps especially built for the purpose, insulating jackets which reduce the time and cost of unloading, etc., there should be little or no demurrage to pay on the tank cars, even in severe weather.

From the above facts it will be seen that, other things being equal, the erection of storage tank and purchase of material in bulk might be an attractive proposition, even to cities which use much smaller quantities of asphalt than are bought by the city of Toronto, as the cost of the tank would probably soon be made up by the savings effected.

The whole question is largely an economic one and must be carefully figured for each city separately. What is profitable in Toronto might not be profitable in, say, Halifax, and vice versâ. The savings effected in Toronto, however, are so large that every city and town engineer who buys asphalt should sharpen his pencil some evening and figure carefully whether investment in a tank would be wise for his municipality, and when his figures are complete, they should be submitted to a competent consulting engineer for checking and further advice.

THE RAILWAY REPORT.

Neither Sir William Mackenzie nor Mr. E. J. Chamberlin appear to be pleased with the majority report of the Royal Commission to Enquire into Railways and Transportation in Canada. Sir William does not admit that the shareholders of the C.N.R. have no equity in their property. Mr. Chamberlin has issued a statement to G.T.R. shareholders, advising them not to be alarmed, and stating that the report contains inaccuracies and misleading statements and that the credit of the Grand Trunk is high and its financial position not at all as stated in the report.

If it is true that the majority report contains inaccurate or misleading statements, full details regarding these should be given to the public and to parliament at once by the Grand Trunk and C.N.R. presidents. The scheme suggested by Messrs. Drayton and Acworth appears sound, but it is such a close approximation of government ownership and operation, and the wall separating the trustees from parliament is so thin, that we should much prefer to see the railways continue as at present if financially possible. If the figures given in the Drayton-Acworth report are even approximately correct, however, there appears to be no possibility of the G.T.R. and the C.N.R. being able to weather the storm without such extensive government aid that it might be unfair to the Canadian people if given without any *quid pro quo*.

The heads of the two railway systems involved should present an outline of their plans for the future, showing that they are independent of undue government assistance and able to carry out all obligations. If their plans are feasible, parliament should let them work out their own salvation, but when advancing further money make certain of ample security. If the railways cannot stand fairly alone, and judging from the Drayton-Acworth report they most certainly cannot, and if the railways do not show any decided errors in the report, the government's course of action is obvious.

The Drayton-Acworth report is, of course, weakened by the fact that it is not unanimous, yet Chairman Smith's minority report cannot be taken with the same degree of confidence as is that of Sir Henry Drayton and Mr. Acworth. In its October 12th, 1916, issue, *The Canadian Engineer* said editorially that Mr. Smith controls important interests in Canada and has affiliations and competitions that cannot but unconsciously color his viewpoint. It was a foregone conclusion in the minds of some people that Mr. Smith would be sure to report exactly as he did. On the other hand, it appeared almost equally certain that Sir Henry Drayton, whose reputed public ownership sentiments were well known, would also report in the manner in which he did. Mr. Acworth was the only unknown quantity, and it is on account of Mr. Acworth's agreement with Sir Henry Drayton that we assign such great importance to the Drayton-Acworth report. Mr. Acworth has never been a champion of public ownership. The strenuous efforts made by the Drayton-Acworth report to get away from government operation, show Mr. Acworth's continued reluctance to recommend the elimination of private ownership. It ap-

pears that there must have been serious, outstanding and convincing reasons for Mr. Acworth's approval of the formation of a Dominion Railway Co.

Mr. Smith's report is very weak compared with the Drayton-Acworth report. The former deals largely with generalities and platitudes, the latter bristles with statistics and logic.

The majority report outlines clearly why the other roads are not turned over to the Canadian Pacific. Probably because the report is not so clear regarding why the Canadian Pacific should not be absorbed along with the other roads, many of the daily newspapers throughout Canada have taken the view that the C.P.R. should also be taken over by the government and merged with the C.N.R. and G.T.R. The C.P.R. is amply able to take care of itself. It is not evading any obligation to the government, nor is it asking for any aid. We venture the opinion that it does not want to be taken over, even if it has to meet the competition of a Dominion Railway Company. The C.P.R. shareholders expect great profits in the future when the population of Canada has been doubled or trebled. Assuming that the government could possibly raise the money necessary to buy out the C.P.R., how could it be done without the consent of shareholders who would have no reason for foregoing large future profits? Compulsory absorption of the C.P.R. would be tantamount to confiscation, and the government cannot possibly afford to make an offer sufficiently attractive to induce the C.P.R. shareholders to surrender cheerfully their bright prospects for the future.

The report is an historic document, and assuming its correctness, presents the Canadian railway situation in a very clear and concise manner. Parliament should not be dilatory in dealing with it, but very discreet. It has made many railway mistakes in the past. It cannot afford to move very far again in any direction in railway matters unless it is absolutely sure of its footing.

PERSONAL.

H. BARON, who has been electrical superintendent at Stettler, Alta., for the past two years, has been appointed chief engineer for the town of Camrose, Alta.

GEORGE BURY, vice president of the C.P.R., has arrived in Montreal from Russia.

R. P. BUTCHART, of Victoria, B.C., has been requested by the Imperial Munitions Board to associate with the Board in its work of shipbuilding on the Pacific Coast. A large organization will have to be formed in connection with the plans decided upon for the building of a great number of wooden ships. Mr. Butchart will act as business adviser and will have supervision of the organization on the coast on behalf of the Board. Mr. Butchart is head of the Pacific Cement Co., Victoria.

JOHN COLLINS, who has been with the Canadian Steam Boiler & Equipment Co., Toronto, has been appointed manager of H. L. Peiler & Company's Toronto office.

V. G. CONVERSE, general manager and chief engineer of the Ontario Power Company, of Niagara Falls, and E. D. KING, superintendent of the plant, have resigned. It is thought these resignations are due to the reported purchase of the Ontario Power Company by the Hydro-Electric Power Commission of Ontario.

GALBRAITH & CATE, LIMITED, engineers and contractors of Montreal, have decided to discontinue business until the return of their managing director and of their secretary-treasurer, both of whom are on active military service.

Dr. LOUIS HERDT, of McGill University, is acting as honorary advisor to the French government in the selection and purchase of electrical supplies. Very large orders, amounting to over $2,000,000, have been placed with Canadian firms, principally wire and cable companies, which otherwise might have gone elsewhere. At the invitation of Dr. Herdt representatives of the French government visited many of our factories and the business referred to above followed.

A. R. HOLMES, formerly secretary-treasurer and engineer of the McKinnon, Holmes Company, Limited, of Sherbrooke, Que., and GEO. H. ARCHIBALD, who has been associated for the past ten years with the Geo. H. Archibald Company, Limited, Winnipeg, have formed a partnership as engineers and builders of reinforced concrete and steel structures, and have opened an office in Toronto.

Lieut.-Col. T. C. IRVING, formerly vice-president of Robert W. Hunt & Co., Limited, engineers, and the Moffat-Irving Steel Works, Limited, Toronto, was recently gazetted as colonel in the 4th Canadian Division. Col. Irving left Toronto with the First Canadian Contingent as a captain in charge of the 2nd Field Company of the Engineers. He received the D.S.O. at the battle of Langemarck, and shortly afterwards obtained his majority.

GEORGE McKNIGHT, city engineer for Fredericton, N.B., has resigned.

P. PHILIP, formerly with the city engineer's department, Vancouver, has been appointed supervising engineer by the British Columbia government for District No. 3 at Kamloops.

Capt. STEWART M. THORNE, a graduate of the School of Practical Science, Toronto, has been decorated for bravery. Prior to his enlistment he was manager of the Trethewey mines, and was well known throughout Northern Ontario. He enlisted with an engineering unit recruited in Cobalt in January, 1916, and has been in France for the past fifteen months. He received his captaincy in the field.

G. L. WALLACE has been appointed structural engineer in the city architect's department, Toronto, to succeed R. J. Fuller, resigned.

J. L. WELLER, M.Can.Soc.C.E., chief engineer in charge of the work on the new Welland Ship Canal, and all his engineering staff, have been relieved of their positions owing to the complete closing down of the work on May 2nd. None of the contractors' plant can be sold without the special consent of the Dominion Government.

R. YOUNG, a gas expert of Pittsburg, Pa., has been appointed manager of the St. Thomas, Ont., gas plant.

WINNIPEG SUB-SURFACE FORMATION.

The regular meeting of the general section of the Manitoba Branch of the Canadian Society of Civil Engineers was held last Thursday evening in the Engineering Building of the University of Manitoba. Mr. Rankine read a paper, "Sub-Surface Formation of the Winnipeg District and the Types of Suitable and Unsuitable Foundations for Its Heavy Structures."

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

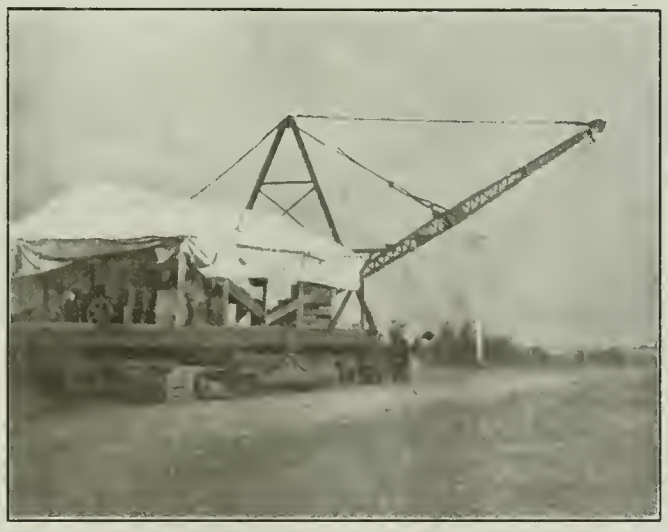
DRAINAGE PROBLEMS IN SASKATCHEWAN

HOW THE CAPACITIES AND LOCATIONS OF THE DRAINS ARE DETERMINED —GRADES AS LOW AS 0.02 PER CENT. HAVE BEEN USED WITH SUCCESS—EXPLANATION OF THE NEW DRAINAGE AND DITCHES ACTS

By CHARLES S. CAMERON, A.M.Can.Soc.C.E.
Dominion and Saskatchewan Land Surveyor, Regina, Sask.

TO discuss the problems or difficulties in connection with drainage work in this province it will be necessary to refer to the laws governing such work, and also give a synopsis of construction already carried out.

Prior to 1909, all drainage was done under the provisions of a North-West Territories Act which was described as "The Public Works Ordinance." This was in force between 1897 and 1909 and was succeeded by "The Drainage Act" and "The Private Ditches Act" of the latter year. The Public Works Ordinance was designed to permit the construction of drains for the benefit of highways only, and it did not provide for any assessment on private lands which might be improved and therefore an equitable distribution of the cost of such work was the chief object in view when the acts of 1909 were passed in the legislature.



The Lount Drag Line Excavator at Canora, Saskatchewan.

The only works done under the ordinance were in districts where it was impossible to proceed with road construction without drainage. A few of these might be mentioned: The Yankee Swamp drain, near Prince Albert; the Dundurn drain, west of Dundurn; the Birch Hills drain, north of Birch Hills; the Kinistino drain, north of Kinistino; the Melfort drain, near town of Melfort; the Yellow Grass drain, south of Yellow Grass.

There was no particular difficulty in the construction of any of these; the average size was from 3 to 6 ft. bottom with side slopes of 1½ to 1 and cost approximating 25 cents per yard. All work, with the exception of a part of the Yellow Grass ditch, was done with teams or by hand labor. The Melfort work was peculiar in the fact that it drained a wet plateau in the centre of which was a small lake. The ground for several miles beyond the ridge surrounding the wet land sloped sharply downward and there was therefore no surface inlet to the lake. No investigation was made at the time or since to discover the source of supply of this water. The deepest cut on the constructed drain was 6 ft., as it was not intended to completely drain the lake. However, when inspection was made in the following spring it was found that the ditch had gouged out to a depth of over 20 ft., and had made a thorough job of drainage.

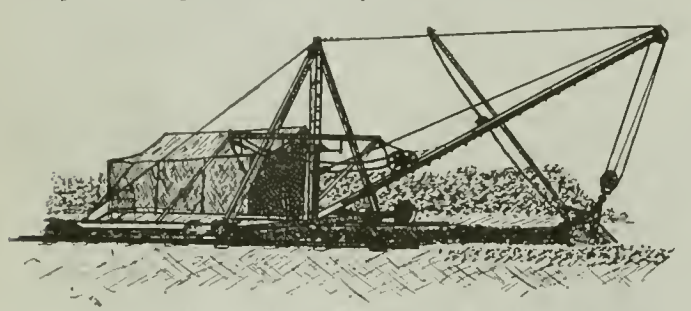
The Yellow Grass ditch was built in 1915. It is 12 miles long with varying bottom widths of from 7 to 18 ft., according to distance from outlet. For about 3 miles near the outlet a floating dredge was used and on this part the side slopes are ½ to 1. The balance was done by team labor and the slopes are 1½ to 1. The upper end is used as a reservoir at times because there is a scarcity of water in the latter part of summer instead of an excess which occurs in the spring. The water flow is regulated by a gate similar in idea to a canal lock. There was no trouble experienced in construction and the only complaint is a claim that the drain should have followed the meanderings of the old creek channel, instead of taking a direct line and straightening the water flow, as was done in some parts.

In referring to the work carried on under the Drainage and Private Ditches Acts it may be pointed out that these regulations are very similar to the laws of the older provinces, especially Ontario, where the Municipal Drainage and the Ditches and Watercourses Acts are in effect; the chief difference being that the municipal councils attend to the administration of both Ontario Acts whilst in this province the provisions of the Drainage Act are carried out by the provincial government. The rural municipality councils of Saskatchewan have charge of the reinforcement of the Private Ditches Act. This is designed to deal with the construction of small ditches, such as those to cost not more than $2,000, and that affect not more than 10 quarter sections of land. The procedure is simple and takes very little time to put into effect. On petition of at least one interested owner the municipal council appoints an engineer to report, and if desirable to proceed, he lays out the work and awards the amount of construction to be done by each land owner or the proportion of cost to be borne by him in the event of the work being done by contract. The chief difficulty with

these ditches is, of course, to get the owners to do their proper share, or in the case of a contractor, he is usually a local man and frequently attempts to use his neighborly influences with the council in order that something "just as good" may be replaced for the real article in the contract. This is ordinary experience and the remedy is in the hands of the engineer. There have not been many private ditches constructed in Saskatchewan, and insofar as I am aware, no successful appeals in court or cause for complaint under the working of this act.

Now to refer to the Drainage Act. This may be discussed under (1) petition, (2) engineer's report, plans and assessment, (3) advertisement and acceptance or rejection by land owners, (4) construction.

The "petition" is an application to the Minister of Highways from the resident owners of at least one-half the area owner by resident owners to have a drain or drains constructed as a benefit to their lands. The work of putting this in shape is usually done by one or two of the more progressive residents and they secure the required number of signatures by explaining the general purpose of the undertaking. The difficulties about having the petition signed are usually not hard to overcome.



Bay City Land Dredger at Lewvan, Saskatchewan.

New settlers from countries where taxation is heavy sometimes hesitate to sign until they understand the method of assessment and collection. A few look upon this class of work as a government undertaking and think that cost should be borne by the province at large, but when it is pointed out that the fair method of apportioning this cost is for the people benefited to pay for the improvement and the province is giving assistance by financing and carrying out the work, their objection is nearly always withdrawn.

On receipt of this petition regularly signed and properly verified, the Minister appoints an engineer to prepare a report, plans, specification and estimate of cost, together with an assessment (or apportionment of cost) to be borne by each parcel of land affected.

The engineer usually arranges to make this survey in the fall or early winter immediately after freeze-up, when he will be able to go over any part of the wet land with the least difficulty and before there is snowfall to any extent to prevent inspection. At this time the location of line through sloughs can be made more accurately as the topography of the lake or slough bottoms can then be easily determined by test holes through the ice.

When on the ground, he first makes an inspection of the wet land, estimating the acreage which might be benefited and securing a rough valuation of the improvement if drainage were effected. A preliminary estimate of cost is obtained by level and stadia survey and this information can usually be secured in three or four days' time on an ordinary survey. In connection with collecting this data, it is not at all wise to depend upon the knowledge of residents as to flow of water as it is quite a common occurrence to hear arguments between neighbors regarding which way the run-off occurs in water courses within a mile or two of their homes and usually each person is quite emphatic in his views and convinced that he is correct, whilst his neighbor may be equally certain that the flow is in an opposite direction. However, when the engineer is satisfied with the main points a comparison is made to determine whether the cost of the proposed work will exceed the benefit to be received and if this is the case it is his duty to discontinue the survey and report adversely regarding the scheme. In the event of the work appearing to be feasible and of advantage a detailed survey is made.

From the information already obtained the main route in general is determined. It is usually best in this province to select the deep points in the lakes or sloughs and establish the route by connecting these points and carrying the drain to an outlet by a line which will make the least yardage excavation and be the most efficient from a standpoint of maintenance. It is of advantage to have this main drain as direct as possible but if this entails a yardage figure very much in excess of following another line on which the ground levels are lower but which is more circuitous, it may be doubtful as to which is best to adopt. The latter route may be objectionable in cutting of land into parts which are awkward to farm but the engineer must consider the valuation of the land, which is, on an average, about 35 per cent. in Saskatchewan of the price in the older provinces, and also excavation cost, which is about double the cost of work in Minnesota or Ontario. These factors, along with any differences in maintenance estimate, have largely to do with the main direction of the drain. Before finally disposing of this, however, he should consider whether the drainage can be done with good effect by ditching along the road allowances because it may be practicable to build a grade for public travel at the same time as the drain work is done by using the excavated material for road purposes. Therefore, the difference between the cost of drainage with and without improvements to roads should be figured on to find if the extra road work is warranted by the extra benefit which might be received. In drains constructed under the Act so far, it appears to be good practice to build the drains along the road allowances only where the district is very level and the roads on low-lying ground. In many cases where fairly deep cuts have been made along the road allowances, it has been found necessary to go to considerable expense in cleaning; and the presence of large open ditches along travelled roads are undesirable from a standpoint of safety.

The main direction having been decided, the engineer proceeds with an exact location; that is, where best to commence and the extent of the work, also how much outlet work is to be done. The outlet may be a lake, river or watercourse of any kind. Levels should be taken for a considerable distance beyond the point necessary to discharge the water in order to make certain that damage should not be done through flooding, or if any is done, to ascertain the extent of this. Notes should be made as to whether banks of outlet streams or lakes are well confined, also if there are any flats or low-lying ground below the outlet and this information may be conveniently shown on a contour sketch plan and retained as a reference in event of any later action for damages through flooding, or the information may be used in case it is decided in later years to extend the drain. In Saskatchewan it has been considered the better plan on the engineer's part to carry the drain to an outlet sufficiently safe to avoid any probability of damage resulting, rather than attempt to

economize in outlet construction by saving yardage cost and paying compensation to the landowners. This latter method entails a direct valuation of property and also the effect which the drain will have (or has had) may not be clear to the owners and for these two reasons a dispute is almost sure to occur. Therefore, to avoid this difficulty, particular attention should be paid to the termination of the drain.

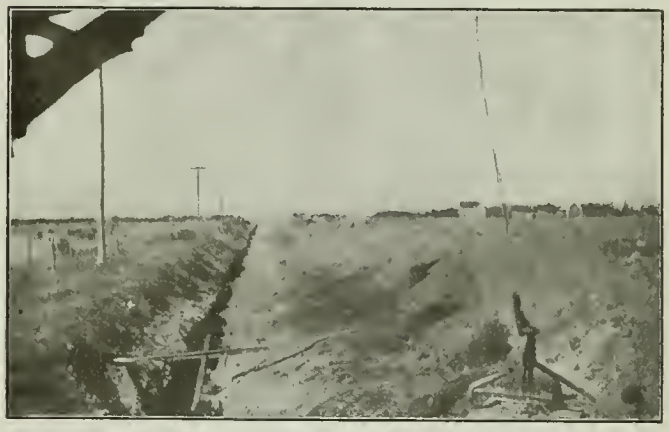
The amount of main ditching on the wet land and also the number of laterals to be constructed is primarily dependent upon the amount of wet or flooded lands in the watershed; also the slope to the outlet and the feasibility of connecting such lands. If there are numerous sloughs separated from the main body of water or much land to be benefited by connections to the main drain or drains, the engineer should consider the extent of minor work and whether this can be done to best advantage by a contractor or by the land owners. Owing to the lack of knowledge of handling the construction of these laterals by the residents and frequent difficulty in securing local labor to attend to this minor ditching work, it is generally advisable to have all laterals dug as part of the contractor's work. There is one drawback to this by reason that the laterals frequently have to be dug after construction of the main drain and this means delay for the contractor and possibly a higher yardage price for the job. Therefore, full information as to class and cost of local labor as compared to regular contract work is necessary before deciding the extent of ditching.

Another difficulty occurs at places where the flow of water in a watershed is interfered with by railway grades. In many cases these grades have been built at times of high water and culverts have been placed too high as well as being omitted where required. The result is that an extra cost in drain crossings of railways is incurred by having to put these improvements on the railway right-of-way. In doing this work the drainage district is put to expense in paying for something that the railway company should have done in their original construction work. It is nearly always difficult to assess the railway company so that they will pay their proper share of such work because of lack of definite information regarding such matters as maintenance-of-way cost in this province. Therefore, the presence of a railway grade is a drawback to the development of drainage work unless the company appreciate the value of the work and assist in bearing a share of the construction cost as well as facilitating the work around their right-of-way. The rights and attitude of the railway company in each case should always be investigated before finally deciding on details near their grade.

Another factor to be noted is the permeability of the soil. In the case of some bodies of water the percolation is very rapid and by noting this the amount of ditching required may be reduced. If the water levels on unconnected sloughs (that is, on the surface) are the same or very nearly so after heavy rains, it may be safely assumed that the lowering of the water level of one will quickly affect that of the other. Test borings of the soil should be taken to make certain if the engineer is considering whether such ditching is necessary.

The above points, along with the general rule of making all laterals "pay for themselves," will largely help to decide the length of the drains. The capacity and design of the drains, also of the culverts and bridges necessary, is usually the most difficult to determine. These points, along with the grade to be used, are decided by the following: Size of the drainage area or watershed; the topography of the area; information as to rapidity of run-off obtained by gauging discharge of watercourses in the watershed; the soil, firmness and permeability; presence of timber, brush or vegetation; rainfall and evaporation; availability of means of construction, whether dredge, dry land excavators, ditching plows, teams or manual labor.

In deciding upon the grade it has been noted that as low as .02 per cent. has been used with success. This is on account of head acquired through rapidity of run-off. This is in turn due to absence of timber and brush and a sharp slope of drainage district to the drain or drains. In the case of one drain with above conditions it has several times become filled with fine particles of summer fallow but the first rush of water cleaned it out as thoroughly as if the grade of the drain had been many times as steep and therefore there would be no advantage in this particular case in having a greater fall. The average condition in the province calls for about .05 per cent. and this has been used most frequently with the size of drains so far constructed.



Drainage and Road Work at Canora, Saskatchewan.

In considering the cross-section area of drain and also size of culverts, it is not at all safe to apply formulæ derived from a knowledge of conditions elsewhere to arrive at the amount of water that will be delivered to the drain from a known watershed area in a given time. By doing this it is altogether likely that the engineer will have the capacity too small, as the early run-off is generally much faster than in the drainage areas from which the standard formulæ were obtained. At present we have not enough data to adjust the formulæ to suit conditions in this province and must therefore rely largely upon information obtained by measuring the discharge of watercourses in the locality and the size of the drain can be computed by a comparison of the respective watersheds.

The above-named points will be important in deciding the details of the plans and profiles, and it is then necessary for the engineer to make up an assessment to cover the cost of the work.

The assessment is an apportionment of cost based upon the benefit received by the owners of the land drained. The method employed is very similar to the Ontario regulations, the main difference being that in Ontario the engineer usually bases his assessment on amount of benefit to be done, together with individual estimates of the cost for doing separate sections. That is, a parcel which is near the outlet on which there are 100 acres of wet land which might be easily drained, would be assessed considerably less than the same area further away and more difficult to drain. It has been customary in assessments in this province to regard direct benefit

almost solely, and not to consider the cost of individual sections. This is a debatable point and we have so far no legal decisions to interpret the exact meaning of the governing Act.

Another point which causes difficulty is to determine the location of the line where benefit from drain ceases. It has been sometimes suggested that only the wet or flooded area can be properly assessed, but this is not equitable, especially in a flat district, and therefore agricultural lands which are made more useful by subsoil drainage should be made to bear a share of the cost. In making assessment on such lands, the engineer should be particularly careful to have very complete information as to land levels, valuations and suitability of soil for agricultural purposes, and be able to supply data to prove that such lands would be benefited. This is, in my opinion, the most likely point in the assessment to be disputed.

In making assessments on municipalities, they are usually arrived at by estimating the saving (or benefit) through drainage in grading, bridge and culvert work and maintenance of all highways which would be affected. This applies to roads which are considered as necessary in the district and does not refer to all road allowances. (The assessment on municipalities so far in Saskatchewan has been from 20 to 40 per cent. of the cost of work and none so far have been disputed.)

The benefits to each parcel and to the municipalities affected are then totaled and this amount is divided into the cost, giving a percentage rate, and the assessment for any individual parcel can then be arrived at by multiplying the estimated benefit by this percentage. The plans, profiles, estimate of cost and assessment are then prepared and submitted to the Minister of Highways, who notifies all interested owners by advertisement that it is proposed to carry out such work and as to what the cost to each parcel is estimated to be. It is now necessary for an owner to appeal against the carrying out of the work if he has any objection and provided that the resident owners of at least one-half the area of resident owners still desire the improvement, it is proceeded with. It might be noted that the resident owners have the entire authority in deciding whether they secure the improvement or not. The difficulty in this is that the resident owner must estimate what effect the drain will have, as he must satisfy himself on this point in order to pass upon the scheme intelligently.

In the construction work there has been no peculiarities different from construction elsewhere, the main drawback is the short season, as ditch work can only be successfully carried on between May 15th and about November 10th. This explains the high excavation cost in this province.

The floating dipper excavator, the dryland dipper excavator and the Lount drag line excavator, have been used with success and it is not necessary to describe the details of these machines as they are in common use in various provinces.

There have been twelve drains constructed under the Act so far and the effect of these is being recorded by inspection from time to time in order that improvements may be made in future work. In connection with the carrying out of certain proposed works the question of method of assessment from lands which have not yet been filed on (owing to these being lake or slough bottoms) has not been finally settled and when this is arranged for several large undertakings will be proceeded with, and with these being carried out we may look forward to valuable additions to the agricultural lands of this province.

THE CANADIAN RAILWAY PROBLEM.*

By Sir Henry L. Drayton, K.C.,
Member of the Railway Inquiry Commission.

THE Canadian railway problem is a vast one and cannot be shelved by any temporary expedient. Mere drifting, the gift of a few more millions here and there will merely add to the difficulties of the situation when the final day of settlement comes, as come it will. The subject is too large for me to attempt to cover in the time at my disposal but I desire to specially call your attention to a few outstanding considerations.

In the first instance, I draw your attention to the great investment the country has already made in railways. Including subsidies, gifts, guarantees, moneys realized from land grants by companies and also the sum expended in government construction, the country's investment amounts to $968,451,737. In these days of terrific war efforts and expenditure, millions and even billions are apt to lose their proper significance. The total amount I have quoted is not final, as it does not include the value of unsold lands granted as bonuses, the value of which is over $100,000,000.

Let us, however, deal with round figures and take one billion dollars as representing the total amount the country has provided for railway purposes. The significance of this sum is hard to grasp.

Toronto is no mean city. Toronto's present total assessment for land is $289,084,898, and for buildings $218,434,573. Notwithstanding the city's area, improvements and importance according to the valuation of your assessment department, it takes two Torontos to cover the country's transportation contributions.

Notwithstanding these enormous contributions, railway necessities were never since Confederation greater than they are to-day. The people of Canada to-day own the National Transcontinental, costing $159,881,197; the Intercolonial, costing $116,234,204, and the Prince Edward Island, costing $9,496,567, resulting in a total of $285,611,968. Deducting this from our total of $1,000,000,000, you have no less than $714,388,032 supplied either by the public credits, moneys or lands for the purposes of railway companies privately controlled and more, much more, is required.

We stand at the parting of the ways. Shall the country again accept the estimates of the companies and supply them with further fortunes, or shall the railway facilities of the country be co-ordinated to the fullest extent necessary to meet the exigencies of the situation and the wasteful duplication of lines and terminals at the country's expense cease? Can the country afford, in view of war obligations—in view of the necessity universally admitted of the strictest national economy—to supply all the money required for company expansion? I confidently submit that to state the question gives the answer. Because the issue is so large and important it is all the more necessary that it be faced boldly and with courage by the country. Every citizen ought to acquaint himself with the facts. It is your business, it is your money, and your future that may in no small regard depend on an honest, fair and proper solution of the question.

I would like everyone to carefully read and consider the railway reports—Mr. Smith's just as carefully and sympathetically as that signed by Mr. Acworth and myself.

*From address before the Canadian Club, at Toronto, May 10th, 1917.

We, Mr. Acworth and myself, have given our honest opinion and best judgment. Mr. Smith has undoubtedly done the same. No conclusion ought to be made until all aspects have been fully and fairly considered.

But I plead for fair consideration for that and nothing else. My only interest is that the right conclusion be arrived at after full consideration and with a full knowledge of the matter by the people of this country. Among other matters this surely means that all party and political bias be abandoned and that the question of whether the Conservative party was wrong here or the Liberal wrong there can have nothing to do with the proper solution of our present difficulties.

Nor can the question be properly settled, as I notice it already has by at least one writer, on the ground that the only practical railroader in the commission was Mr. Smith, and that as Mr. Acworth and myself were merely students of and theorists in railway matters, Mr. Smith's conclusions must perforce be adopted. May I at this point ask what is responsible for the present situation? Too much study and consideration of the problem from the country's standpoint or too many practical railroad builders anxious to build railways anywhere or everywhere when the essential government assistance could be obtained?

Let me at once say that in my view the government could not have found a better or more efficient railway operator than Mr. Smith. As to myself I say nothing; except that for months past my time has been very much taken up in looking after the supply of coal, grain, flour and other necessaries of life, of agriculture and of the manufacture of munitions and other essentials. I can at least say that in no instance did the shippers or consignees look either upon their necessities or my intervention on their behalf as theoretical or academic.

I would like, however, to acknowledge the assiduous and thorough work of Mr. Acworth, whose training, disposition and ability particularly well fitted him to pass on the question. I admit that Mr. Acworth is a student. I go further and say that he is a great student of and a recognized authority on the whole question of railway economics, that he has written leading text books on the subject and that in the opinion of the practical railway managers of America his knowledge and his standing is such that he has been engaged by them to give evidence this very week on their behalf before the Congressional Committee on Transportation at Washington on the evils of political railway management. I attach the very greatest importance to Mr. Acworth's conclusions, particularly in view of the fact that he is very familiar with company management and English finance, and that he himself is a director of the Underground Railway of London, which controls the bulk of the transportation facilities, both street and underground, and omnibuses in and around the metropolis.

The whole issue is, what is right, what is in the best interests of the country, not what is popular and the most easy to put into effect. Public opinion may roughly be divided into two classes: Those who believe in public ownership and operation of all public utilities and to the fullest extent, and those who believe that only proper results can be obtained by individual initiative and effort in the hope of individual gain, and who also believe that everything that the government takes in hand will be more or less muddled. In some sections of the country the one view is popular and in others the other.

We have made no attempt in our report to meet the views of either section. We deal with conditions and not theories. Our report leaves the Canadian Pacific standing as it is. This naturally affords the thorough-going public ownership advocate a ground of complaint and also enables pro-corporation adherents an opportunity for attack. Let us for a moment consider what public necessity and right now insistently calls for.

The most urgent necessity is better and more efficient transportation. The most pressing failures that have taken place are attributable to the Grand Trunk and to the Canadian Northern. It is common ground that both systems urgently require many more locomotives and many more freight cars. The report made by Mr. E. E. Loomis and Mr. John W. Platten, as I understand it, at the instance of the Canadian Northern, points out that the Canadian Pacific has two and two-tenths times rateably the number of locomotives owned by the Canadian Northern and has nearly two and three-tenths times rateably the number of freight cars. No such case is made out against the Canadian Pacific, but again every one has conceded that that company is giving an efficient public service and is well and efficiently organized.

The Canadian Pacific stands well in the world's financial circles and has a great borrowing power as well as liquid assets held in reserve. At a time like the present it is undoubtedly in the best interest of the country that the company's borrowing power and financial ability to increase its facilities be not impaired, and further, that any new capital that may be required for the Canadian Pacific undertaking ought not to be obtained on the credit of the country generally, as might be the case should the company be taken over and its liquid reserves divided among its shareholders. More or less difficulty attends any change—mistakes of detail invariably occur. The Canadian Pacific service is good and satisfactory. It is certainly not necessary under the present conditions to jeopardize it.

In so far as the other systems go, the conditions are reversed. Service is poor. Transportation failures have taken place, and no company funds are available to make them good. In addition to this, no further capital investment would be saved by taking in the Canadian Pacific whose service and facilities are, speaking generally, complete both in the East and West. On the other hand, the Grand Trunk is well-established in the East but lacks necessary feeders and terminals in the West, while the Canadian Northern has a well-laid-out system in the West, but is sadly lacking both terminals and lines in the East. The two systems combined, as we suggest, renders unnecessary Grand Trunk work in the West and Canadian Northern work in the East.

Two objections have been made to our conclusions. The one that it is impossible for the new National System to compete with the well-established and efficient Canadian Pacific and that public ownership must under such unfair conditions fail. All I can say is that if the National Railway System cannot stand in competion with a privately owned system, the sooner the fact is demonstrated the better. We seek to improve conditions and not to create an inefficient substitute merely for the purpose of making a change.

The other objection, equally strongly taken, is that the competition of the National System would be unfair to the Canadian Pacific. Manifestly the one objection answers the other. I believe neither are well taken. The competition would be unfair to the Canadian Pacific if the National System were not run on business principles and rates were not levied having regard to the cost and value of the service, but were in part covered by the

general tax levy. With the safeguards we suggest observed, no dishonest competition can or will take place.

Then again, is it not well to have a yard stick with which to measure the performances of your railway administrators? Railways—successful railways—never can stand still. Facilities must from time to time be enlarged, practices changed to meet new conditions, extensions of usefulness in all directions made in order to properly cover the ever-increasing demands of public service. The country's successful line, the Canadian Pacific, is an illustration of this fact. Undoubtedly its usefulness will increase in the future as it has in the past. The National Railway System will not properly serve the public unless progress and increased facilities and potentialities characterize all its activities. There will be but little danger of lack of effort in this direction under the spur of an intelligent and effective competition and little danger of paralysis and dry rot resulting from political interference and the patronage system. Over and above all other considerations the underlying public necessity, transportation, will not be unnecessarily jeopardized.

As I have already pointed out, we deal with conditions and not theories. The conclusions we have arrived at are the logical results of existing conditions, not of the application of theories. The Grand Trunk itself says it is at the end of its tether. It is impossible for it to carry the burden of the Grand Trunk Pacific. The cost of that system, as returned to the government February, 1910, amounted to $197,129,590, and of this sum $123,000,000 represents the commitments of the Grand Trunk proper, either cash or credits. The only other financial interest, ranking as it does for the most part in priority to all Grand Trunk claims, is that of the country. The application of public ownership is hardly in question. The country, in fact, owns the system already. Its position is in effect that of a first mortgagee whose security is hopelessly in default with no hope of a redemption. Shall the country assume the interest obligations and the responsibility for operating losses on this line, which, standing by itself can yield no proper returns to the country, or shall the property be made valuable and useful by including with it the Grand Trunk, the necessary eastern connections?

The original scheme certainly contemplated one system, construction in the West to supplement the system in the East. Separated from the West, the Grand Trunk itself cannot discharge the full measure of public service. The recognition of this fact caused Mr. Hays and his company to build their western system. Undoubtely in the public interest the system which was intended to be one and complete must be so operated and this the Grand Trunk itself says it cannot do. In view of essential public necessity you are driven by the acts of the Grand Trunk itself to public control.

Then as to the Canadian Northern. The total amount of public assistance, direct and indirect, amounts to the sum of $298,253,263. This sum is over $12,000,000 more than the country's investment in the National Transcontinental, Intercolonial and Prince Edward Island railways. Again the country is in the position of the mortgagee, not only with securities in default, not only without any present hope of redemption, but faced with the fact that to put the system in working order, experts reporting for the company report that new capital required for a minimum program for three years amounts to $54,000,000, and for their maximum program for a five-year period, $80,000,000.

Parliament in 1914 authorized the guarantee of the company's securities to the extent of $45,000,000. The guarantee was secured by mortgage and under the provisions of the Act the Governor-in-Council has power, when authorized by parliament, to declare by order, if default is made by the company in payment of interest, that the equity of redemption of the company is absolutely barred and foreclosed and thereupon the whole property becomes vested in the Dominion. Defaults have been made, defaults continue. Why should the company not be held to its obligations? Why should it, particularly at a time like the present, receive further bounty? Why should the country's money be expended in the construction of eastern lines and terminals largely unnecessary if the system be operated in conjunction with the Grand Trunk?

We all recognize the evils of political management of public undertakings. Under our plan these evils are entirely eliminated. We propose the application of business methods—the most approved company methods—to the transportation problem. It ought to be run on business lines. There ought to be no cabinet or parliamentary interference, there ought to be no political patronage. I am confident these results can be obtained. If they cannot, then the defects of our system of government must indeed be grave, our common honesty and fixity of purpose sadly lacking.

I do not believe that one parliament will wrongly undo the work of another, as is suggested. Our plan is termed by the opponents of the system, "fantastic." It is the plan adopted almost universally by the companies themselves in order to obtain a proper continuity of policy and efficient management. Company directors themselves nominate their successors for election by the shareholders. We simply adopt company methods where tried and found effective in carrying out the public business.

MANY MONTREAL ENGINEERS VOLUNTEER TO AID IN RESEARCH WORK.

The Montreal members of the Canadian Society of Civil Engineers held a meeting last Thursday evening at the headquarters of the society for the purpose of discussing the collection of information for the Honorary Advisory Council for Scientific and Industrial Research. Members of the Canadian Mining Institute and of the Society of Chemical Industry also attended, as these societies are co-operating in the work.

Prof. E. Brown explained that a list of 1,500 manufacturers in Montreal had been received. These had been subdivided into wards and districts and thirty teams would be appointed from the three societies, each team comprising about six members, to make a personal canvass of these manufacturers in order that the full information asked for in the questionnaires may be obtained so far as possible. Prof. Brown will have charge of the work of the teams.

The captains of the teams are as follows: E. Marceau, A. Surveyer, J. C. Smith, J. M. Robertson, R. M. Wilson, deGaspe Beaubien, J. T. Farmer, J. S. Costigan, O. O. Lefebvre, H. Rolph, K. B. Thornton, F. B. Brown, E. E. Fraser, W. D. Black, F. H. Pitcher, A. F. Byers, R. deL. French, G. R. McLeod, W. W. Plumb, Lieut.-Col. C. N. Monsarrat, M. Beullac, A. R. Roberts, H. Y. Russell, J. W. Bell, J. A. Dresser, Capt. J. G. Ross, Dr. Milton Hersey, Leo. Ryan, C. A. Hazen and J. A. DeCew.

AMERICAN WATERWORKS CONVENTION.

(Staff Correspondence.)

Richmond, Va., May 11th.—The Thirty-seventh annual Convention of the American Waterworks Association opened Monday evening, May 7th, in the auditorium of Hotel Jefferson, Richmond, Va.

It is exactly eighteen years since the association last held a meeting in the historic city of Richmond. At that meeting only ninety-three active and fifty-four associate members were present, while at the meeting just closed there was about five times that number present. Among the active members who were elected at the 1900 meeting, and who are still enthusiastic members, are Howard A. Dill, of Richmond, Indiana; James M. Caird, the present treasurer, and F. J. Connor, of Fariboult, Minn.

The address of the retiring president, Leonard Metcalf, of Boston, was devoted in large part to the need for a greater spirit of co-operation on the part of the entire membership in the effort to solve the problems incidental to the work of the average waterworks engineer. It was a plea for the "get together" spirit in the work of an association, which now numbers about 1,350, of which btewcen 70 and 80 are resident in Canada. In his address Mr. Metcalf deplored the lack of complete co-operation among officers, committees and members, and warned against the creeping in of local cliques.

Among other things, he suggested that larger powers be given to the officers; that the committees be assigned more definte duties; that committees be instructed and authorized to carry on all correspondence in manifold; that all meetings of the sections be attended by at least one member of the executive committee of the mother organization.

Following President Metcalf's address, R. E. Milligan, president of the American Waterworks Manufacturers' Association, presented—on behalf of the Manufacturers' Association—a very handsome silver cup, which is to be competed for annually in a golf tournament. The successful contestant at each annual meeting of the American Waterworks Association is to receive a miniature reproduction of the large cup, and is also to have his name engraved on the large cup, which is to be retained by the American Waterworks Association.

The program for the first day of real convention, May 8th, included announcement of officers elected for 1917-1918, and also eight papers, with discussion. Officers for the ensuing year are as follows:—

T. A. Leisen, Detroit, president; A. W. Cuddeback, Paterson, N.J., vice-president; James M. Caird, Troy, N.Y., treasurer; D. A. Cramer and B. C. Little, trustees.

The first paper was by John W. Alvord, entitled, "Recent Tendencies and Progress in Waterworks Practice." While he admitted that much of the improvement in standards is due to inspection, he expressed the opinion that those improvements are more due to filtration.

Having been called into active service, John D. Kilpatrick was not able to read his paper, entitled, "Water Supply for Military Camps."

Clarence Goldsmith's paper, "Reliability in Pumping Station Design," judging by the discussion wihch followed, was almost too ideal to be practical. That, at least, appeared to be the opinion of those who took part in the discussion.

Leonard A. Day's paper, "Improved Efficiency of the St. Louis Pumping Station," was illustrated by lantern slides.

O. A. Doane, by his paper on "Pumping Station Costs," brought out a considerable amount of discussion.

W. C. Hawley's paper, "Relation between Water Departments and the Public," was presented by Mr. R. S. Weston, of Boston, in Mr. Hawley's absence.

Tuesday evening a reception was held in the auditorium of the hotel. Music, dancing and refreshments were provided by the Waterworks Manufacturers' Association. Mrs. Claire Spencer, formerly of the Manhattan Opera Company, sang a number of Irish songs, while Clinton Inglee, of the National Water Main Cleaning Co., delighted the company by singing several times.

Wednesday morning's session was devoted to the reading of technical papers, the election of nominating committee, and selection of place for holding the 1918 convention.

The Nominating Committee for 1918 was chosen by districts as follows: Western States and Canada—H. Hymmen, Superintendent Waterworks, Kitchener, Ont.; New England—R. S. Weston, Boston, Mass,; Middle States—C. R. Wood, Millville, N.J.; Southern States—J. A. Steele, Vicksburg, Miss.; Central States—John W. Alvord, Chicago.

The contest for next place of meeting was between St. Louis, Mo.; Detroit, Mich., and Evansville, Ind. St. Louis won by a large majority.

Wednesday afternoon was given over to a social time. Special cars took about 300 delegates and ladies to the Richmond Country Club.

Thursday morning the superintendents carried on a topical discussion, while the chemical and bacteriological sections held sessions simultaneously. All groups were well attended and much of practical interest was brought out.

These same sections also held afternoon sessions, while in the evening reports of officers and standing committees were received and discussed.

There was only one session on Friday. Reports of special committees were followed by a general discussion of subjects pertaining to the welfare of the association. Friday afternoon the delegates were the city's guests at the Richmond Pumping Station, where luncheon was served.

There were about 430 active and associate delegates present, and about 100 guests, or 530 in all.

Attractive Exhibits.—The Palm Room of the Jefferson Hotel, which was devoted to the exhibits, was filled with displays of waterworks supplies and material of all kinds. Every available foot of space was occupied. There could be seen the latest improvements in filter models, hydrants, pumps, valves, chlorinating and sterilization plants, etc.

PITOMETER CO., NEW YORK.—In charge of exhibit, E. S. Cole, E. D. Case and A. W. Hogeland. Showing Cole Recording Pitometer, new aluminum-case, field type of pitometer for waterworks survey. This is a type recently put on the market.

NEW YORK CONTINENTAL JEWELL FILTRATION CO., NEW YORK.—Represented by R. E. Milligan, Arthur M. Crane and Gilbert H. Matt. This firm's exhibit included a model of a typical concrete gravity filter plant, a model of the Wheeler filter bottom, samples of strainers and laterals, etc.

SIMPLEX VALVE AND METER CO., PHILADELPHIA.—Represented by C. C. Behney, mechanical engineer, and W. F. Harveson, assistant secretary. This exhibit included Simplex indicating, recording and registering Venturi meters, portable pitot tube recorder,

manometer, rate-of-flow controller and other Simplex devices.

R. D. WOOD CO., PHILADELPHIA.—Represented by C. R. Wood, C. H. Becker and John Wistar. Hydrants, valves and fittings.

WALLACE & TIERNAN CO., NEW YORK.—Represented by W. F .Tiernan, A. R. Murphy and R. C. Donnelly. This exhibit showed manual and automatic control chlorinators. They also exhibited for the first time their automatic chlorinator, operated by the pitot tube, also an automatic chlorinator for intermittent use. By the use of a circulating pump much of the apparatus was shown in actual operation.

ELECTRO BLEACHING GAS CO., NEW YORK.—Represented by E. D. Kingsley, J. A. Kienle, G. R. Ellis and H. W. Gochnauer. Among the features of this exhibit were "model C" and "model F" manually controlled portable chlorinators for emergency purposes. A big photo of the newly-enlarged chlorine gas plant of this company at Niagara Falls, N.Y., attracted great attention. It is said to be the largest plant of its kind in the world, having a capacity of over 60,000 pounds per day.

R. U. V. CO., NEW YORK.—Represented by A. T. Smith, sales manager, and H. A. Stillwell, eastern representative. A typical filtration plant sterilizer was shown in such manner as to explain clearly the method of sterilization by bringing the water into close contact with ultra-violet rays.

EAST JERSEY PIPE CO., NEW YORK.—Represented by Grant A. Peacock, showing two sections of lock-bar pipe, one of them dipped, the other dipped and wrapped. This pipe is made in sizes from 20 in. to 72 in. in diameter, and in thickness of plate from 3/16 in. to ½ in.

BIRCH-HINZ MFG. CO., CHICAGO.—Represented by W. T. Birch. A very complete line of specially constructed pump valves with metal inserts.

ROSS VALVE CO., TROY.—Represented by Wm. Ross. "Trojan" pressure regulator valves and reducing valves constituted the main features of this exhibit.

H. MUELLER MFG. CO., DECATUR.—Represented by C. T. Ford. Display of water meter testers, with a multiple tester attached, waterworks brass goods and waterworks tools.

MARITIME COATING CORPORATION, NEW YORK.—Represented by J. Willoughby Mitchell, president. A composition which can be applied cold and forms an anti-corrosive paste. Can be applied either by trowel or dauber.

ALEXANDER MILBURN CO., BALTIMORE.—Represented by C. R. Pollard. Portable lights for trench work.

CARBIC MFG. CO., DULUTH.—Portable lights for trench work.

MULTIPLEX MFG. CO., BERWICK.—Represented by J. F. Casey, manager. Crispin slip joints and Crispin air valves for water mains, pipe lines, etc., attracted considerable attention.

LEADITE CO., PHILADELPHIA.—Represented by Geo. Mackay, Jas. P. Mackay and J. H. Glanding. This firm provided demonstrations of the merits of Leadite as a jointing material for water mains.

CHRIS. D. SCHRAMM & SON, PHILADELPHIA.—Represented by J. W. Gleeson. Portable air-compressors for rock drill work, pipe-caulking and diaphragm-pumping outfits.

PITTSBURGH FILTER MFG. CO., PITTSBURGH.—Represented by F. B. Leopold, general manager, who explained special plants installed by that firm, using drawings and pictures of these plants for the purpose.

KENNEDY VALVE CO., ELMIRA.—Represented by E. Kennedy and Harry Overbaugh. This concern showed "New Type" hydrants and valves.

RENSSELAER VALVE CO., TROY.—Represented by Geo. M. Keefer and John S. Warde, Jr., showing working models of the Corey fire hydrant and of valves.

NATIONAL WATER MAIN CLEANING CO., NEW YORK.—Represented by Clinton Inglee and Burt B. Hodgman. Exhibit consisted of a large number of samples of pipe before and after cleaning.

BUFFALO METER CO., BUFFALO.—Represented by Chas. Bassett and W. J. Chellew. Various sizes and styles of Niagara and American meters.

NEPTUNE METER CO., NEW YORK.—Represented by D. B. McCarthy, Chas. Buchmann and H. F. Bown. Attractive display of "Trident" meters.

PITTSBURGH-DES MOINES STEEL CO., PITTSBURGH.—Showed illustrated catalogues and photographs of elevated steel tanks.

BUILDERS IRON FOUNDRY, PROVIDENCE.—Represented by F. N. Connett, chief engineer, and A. B. Coulters. This firm showed a Venturi meter, set up in connection with a water tank and geared pump.

Canadian Members Who Attended.—The following Canadian members of the association attended the convention: F. C. Laberge, Montreal; F. H. Pitcher, Montreal; H. Hymmen, Kitchener; R. L. Dobbin, Peterboro'; C. D. Brown, Walkerville; Jos. Race, Ottawa; Jas. J. Salmond, Toronto; W. H. Moore, Peterboro'; and W. E. McDonald, Ottawa.

INVESTIGATIONS OF RESEARCH COUNCIL.

That the Canadian Research Council is at present engaged chiefly in determining the extent to which lignite can be used as fuel, was a statement made by Professor A. B. McCallum, chairman of the council, in a recent interview.

"In the United States, Italy and Germany," said Mr. McCallum, "it is made usable by carbonizing. It is put into the form of briquets with the aid of pitch or tar. The question we have to solve is how to make these lignites economically usable. One would think that the same process employed elsewhere would be a success here, but that is not so because lignites are not all the same. The material, for instance, is poor in Saskatchewan and good in Alberta.

"The Commission is also investigating the possibility of utilizing Alberta's tar sands in connection with road paving. Reforestation is another subject of inquiry, as is also the production of potash. "Previous to 1870 the chief sources of potash were seaweed and burnt forests," said Prof. McCallum. "Since 1870 our supply has come chiefly from the potash beds in Germany. This is now cut off. Feldspar rock is looked to as our source of supply, but there is no method at present for putting it in shape for use. Then we have the question of phosphates and their treatment for fertilizers.

"We are gathering information on nitrogen fixation. By that I mean the process of getting nitric acid and ammonia from the air to replace Chilean saltpeter. Nitric acid and ammonia are needed for explosives and for fertilizer. The Imperial Munitions Board has asked us to take up this particular problem."

ROAD LAWS OF ONTARIO.*

By W. A. McLean, M.Can.Soc.C.E.,
Deputy Minister of Highways, Province of Ontario.

THE twentieth century is pre-eminently an age of rapid transportation and intercommunication. The advantages of modern railway, steamship, cable, telegraph and telephone systems would have seemed like Arabian Nights tales to those of our ancestors who crossed the Atlantic less than one hundred years ago. Auspiciously, the advanced road legislation of Ontario had its inception in 1901, thereby taking its proper place in "The Century of Transportation" in which we live.

The road laws of Ontario are based on the excellent municipal system which grew up in the 19th century, and which has created excellent and progressive local self-government throughout the province. Towns, villages and cities are responsible for the up-keep of streets within their boundaries; but the care of roads in the open country constitutes one of the chief duties of township and county councils.

Provision for municipal organization is made by the Municipal Act; which Act defines the general authority of municipal councils with respect to roads. Township councils usually consist of a reeve and four councillors. A county comprises a group of townships, and the county council is composed of the reeves (and deputy reeves) of the townships, towns and villages included within the area of the county.

Township Roads.—Township councils, in the earlier history of the province, depended largely on statute labor for road improvement; this system having been created by the first parliament of the province (then Upper Canada) in 1796. Money expenditure, raised by general levy on the township assessment, has been steadily increasing. At the present time townships are spending annually over $1,400,000 in cash and 1,100,000 days of statute labor, having a total estimated value of $2,500,000 annually.

Township councils have authority to pass by-laws to abolish statute labor. About one-quarter of the townships have done so, while the number is steadily increasing.

The Highway Department is encouraging all townships to place their road expenditure in charge of a permanent road superintendent or foreman, and to this end will pay (under the Ontario Highways Act, 1915) one-quarter of the salary of such an official, the provincial grant not to exceed $150 annually.

County Roads.—Provincial aid to road construction is given principally through county road systems, under the Highway Improvement Act. Twenty-five counties, out of thirty-seven which are eligible, are carrying on construction; having assumed over 5,000 miles of road, of which over 2,000 have been substantially built. Expenditure to the end of 1915 has amounted to $6,000,000 including $1,200,000 for bridges. Work is now being carried on at the rate of $900,000 annually. It is anticipated that all counties will be operating under this plan within a few years, and that the annual expenditure will be doubled. The chief features of this Act are as follows:

A county council is authorized to assume by by-law a system of roads for construction and maintenance, the province contributing 40 per cent. of the expenditure on construction and 20 per cent. of the cost of maintenance.

A by-law adopting such a system may be passed by a two-thirds majority of a county council representing at least one-half of the total equalized assessment of the county.

The roads assumed are usually such as will accommodate the greater part of local market travel, creating a system of main market roads. They are the roads radiating from local market centres and shipping points. They should be connected as far as practicable to serve the needs of through traffic of the locality.

The mileage of roads assumed by a county is usually from 12 to 18 per cent. of the total mileage of the county.

The direction and superintendence of the work is placed in charge of a county engineer or capable superintendent appointed by the county council. A committee of the county council should co-operate with, advise and direct the road superintendent.

Roads are to be built in accordance with the regulations of the Department of Public Highways. The construction should be suited to local material and traffic. A standard type is regarded as a roadway well drained, graded to a width of 24 feet between ditches, with broken stone or gravel in the centre to a width of from 9 to 18 feet, and consolidated by rolling. The cost varies with local conditions, but is in general proportionate to the width and kind of metal. The system of roads assumed, and the by-law fixing the plan of improvement, are subject to approval of the Provincial Department.

When roads are assumed by a county council under this Act, township councils cease to have control over them, nor should they make any expenditure on them. The county council is thereafter responsible for construction and maintenance.

The provincial grant is paid annually, and is based on a statement of expenditure for the year, submitted to the Minister of Public Works and Highways by the county council, and includes all costs of labor, material, engineering services, salary of road superintendent, machinery, and bridges on the designated system of county roads.

The county council may finance their work by issuing debentures for a term not exceeding thirty years; or by sums raised from year to year in the annual county rate. The cost of purchasing and reconstructing toll roads may be included in the expenditure. The county council may by by-law make grants to towns and villages not separated from the county, for the improvement of extensions or connecting links of county roads in such towns and villages, and certain of such grants may be included in the statement of annual expenditure. Grants eligible for a provincial subsidy are those made to villages having a population of 1,500 or less; and those made to municipalities with a population of over 1,500, provided the improvement is carried out on suburban streets.

Suburban Roads.—Provision is made under the Ontario Highways Act, that a city may co-operate with the county council in improving the leading county roads adjacent to the city, and thereby obtain a more substantial type of construction for such suburban roads. The procedure is as follows:

A county council, by resolution, makes application to the Lieutenant-Governor-in-Council asking that a commission be authorized to deal with the suburban roads or portions thereof in the county system adjacent to the city and towards the construction and maintenance of which the city in question should contribute.

The Department of Public Highways submits the application to the city in question and considers their views in the matter. Should the commission be recommended

*Abstract of paper before Canadian and International Road Congress, Ottawa, April, 1917.

by the Department and authorized by Order-in-Council, it is made up of representatives chosen by the city and county council. In the case of a city having a population of less than 50,000, it would be composed of three persons, the county council selecting one member, the city selecting one, and the two agreeing upon a third. In the case of cities of over 50,000 population, the commission would be composed of five persons selected in a similar manner.

The first duty of the commission would be to determine the roads, and the length of each adjacent to the city, to which the city would contribute; the commission forming a board of arbitration for that purpose. It is then the duty of the commission to determine the work to be undertaken each year and to estimate the amounts required for construction and maintenance.

The county council would first approve or amend this estimate and authorize expenditure. It is then the duty of the county council, not later than the first day of March in each year, to notify the city of the amounts required.

For construction the province contributes 40 per cent. and the county and city each 30 per cent.; for maintenance and repair the province contributes 20 per cent. and the county and city divide the remainder equally between them.

The section of county road designated as "suburban" remains a county road for which the county is responsible; the work of construction and maintenance to be carried on under the county road superintendent but subject to the instructions of the special commission.

Provincial Highways.—A system of provincial highways has been authorized by a recent Act of the legislature, with a view to the construction and maintenance, under the Highways Department, of a net-work of leading highways throughout the province. A highway from east to west across the province would be the main artery of such a system, with suitable connecting branches leading to other parts of the province, and joining up county towns, cities or other important terminal points.

The Act gives the Provincial Highways Department, with the approval of the Lieutenant-Governor-in-Council, power to take over on behalf of the Crown any public highway by filing a route plan of the road in the local registry office and giving notice in the Ontario Gazette.

The department, through its officers, is thereafter responsible for the proper construction and maintenance of the highways so assumed. For this purpose the department has the usual powers of municipal corporations to widen or deviate the road allowance, procure material for construction, purchase machinery, and in general to control the use of the highway under the usual responsibilities placed upon municipalities.

Adjacent to cities the cost is borne in the proportion of 40 per cent. by the province, 30 per cent. by the city, and 30 per cent. by the municipality through which the road passes. Outside of the suburban section, the province assumes the proportion levied on the city, thereby paying 70 per cent., and the local municipality 30 per cent. In the case of bridges, the local municipality is placed on the same basis as in the case of a county road, *viz.*, the local municipality pays 60 per cent. of the cost of a bridge suitable for county purposes, and the province pays the balance. In cases where a special type of pavement is desired by a locality, provision is made for levying any excess part of the cost on a frontage basis. Various contingencies are provided for; with, in general, a right of appeal to the Ontario Railway and Municipal Board.

All cost of surveys, the purchase of machinery, plant and equipment, land for widening or deviating, general overhead and staff expenses are to be borne entirely by the province. Thus the local municipalities will be, in effect, required to pay less than 30 per cent. of the total cost.

A fundamental basis upon which the cost is thus distributed is that each local community should be required to pay for a road suited to local requirements. It is unfair to the rest of the province to levy less than that amount. It is unfair to the local municipality to require it to pay the entire cost of a road carrying an excessive amount of through traffic. The difference between the cost of a road suited to local requirements, and one of a character suited to the traffic of a main road, is therefore to be levied upon cities immediately served, or is to be met by the province from the revenue from motor vehicles. A main road from the county of Essex to the Quebec boundary, with branches to St. Catharines and Ottawa, passes through urban and rural municipalities having half the population of the province and over 60 per cent. of the assessment.

The building of the provincial highway system will not be undertaken as a huge work of continuous construction, but will be a matter of gradual development and extension. Wherever conditions are favorable, systematic maintenance will be applied so as to make the most of any reasonably good sections as they now exist. Construction will be taken up in sections where traffic is especially heavy, or where the road has heretofore been neglected. One type of pavement throughout is not contemplated. An effort will be made to construct in proportion to traffic, making the best possible use of local materials.

The immediate need is for a reasonably good trunk road system, joining up cities and local road systems, and making it possible for each local community to be a unit in such a trunk system without carrying an excessive or burdensome share of the cost.

Provincial County Roads.—Co-operative with provincial roads, but under county control, certain roads may be designated by the Highways Department as "Provincial County Roads." To such roads the province will contribute 60 per cent. of the cost of construction, and maintenance. These roads are intended to enable the more equitable maintenance of certain county roads, carrying a considerable proportion of through traffic, but which the county may efficiently maintain, and which are not of sufficient importance to be classed as provincial, or which it is not desirable or expedient for the province to assume as provincial highways. They continue to be county roads, but because of heavy through traffic, receive an increased subsidy.

Cities Share in the Cost.—Suburban roads and the assessment of cities for main road improvement is a feature of Ontario legislation that is new to most parts of the province, and the reasons for such requirements are of interest.

The development of main highways has, in every county required the co-operation of cities. This has been true in countries of Europe, such as England, France and Belgium. In the United States, the city of Detroit is paying 85 per cent. of the cost of roads in Wayne County. Cleveland is paying $800,000 annually for road construction outside of the city. In New York, the cities are paying 85 per cent. of the State expenditure. Similar conditions exist in other States.

In the case of cities in the United States, they are as a rule not separated from township and county or-

ganization, so that a considerable part of their expenditure on main roads is automatically arranged. In Ontario, however, with cities separated from township and county organization, it has been necessary to devise the system of suburban road contributions provided for in the Ontario Highways Act, in order that the existing municipal organization might not be disarranged.

Roads should be built and maintained in proportion to the traffic over them. Roads within two or three miles of a city may cost two or three times the ordinary expenditure of the county on roads, and this extra cost is difficult for the county to finance without co-operation from the city.

The object of a city's contribution would not be to relieve the county of the expenditure which they are now making, or which they may equitably be called upon to make, but rather to improve the standard of roads radiating from the city, and to permit them to be maintained in a condition suited to the traffic over them. Traffic accumulates to a considerable density on the main roads immediately adjacent to the city, and it becomes an unfair charge upon rural districts to construct and maintain roads suited to such accumulated traffic.

Thus the county with provincial aid may be spending for ordinary roads $5,000 per mile; made up of $3,000 from the county and $2,000 from the province. By calling upon the city to contribute equally with the county, the two provide $6,000, which entitles them to a provincial subsidy of $4,000. In this way, roads costing $10,000 (or $20,000) per mile become possible, to the very great advantage of the cities.

Municipal boundary lines are purely arbitrary and accidental. It cannot be maintained that the true interests and obligations of cities do not extend beyond their boundaries. That city councils are inclined to think of their interests as terminating with the city boundaries is purely a traditional attitude of mind, and in considering the advantages of good main roads, is without basis of fact. Good main roads are a means of rural development and are a source of local trade, as well as a convenience to city residents. The construction of main highways radiating from a city is so clearly of advantage to the city, that artificial boundary lines must necessarily be disregarded in providing equitably for the cost.

It has been suggested that the province should contribute to the cost of continuing main roads through a city. But wealth is concentrated in cities. Cities in Ontario have an assessment of $1,033,117,544 and a population of 1,019,627; whereas townships have an assessment of $687,372,853 and a population of 1,027,220. With the comparatively small amount which cities are asked to pay to the construction of main roads radiating from them, we believe that ample consideration is given to the construction of connecting links within the city at the cost of the city.

A man's farm bears a somewhat similar relation to a public highway that the streets of a city bear to the system of county roads. We aid a farmer to build roads to the boundary of his farm, but do not aid him to construct lanes and driveways on his farm. If a farm of 100 acres with a single family residing on it, and distant two miles from a county road, is taxed for the construction of such a main road, it would seem only fair that an area of 3,000 acres and containing a population of 25,000 with a valuation equal to 6,000 farms, should pay something to the cost of main roads radiating from it.

The building of expensive pavements within a city does not absolve the city from its obligations with respect to main roads in the open country. City pavements are not designed for traffic requirements; but are expensive largely because of the advantages of curbing and good boulevards to adjacent property; the cost being reflected in increased property values. Comparing a $4,000 per mile road in the country with a city pavement costing $60,000 per mile, under ordinary conditions of land occupation in Ontario, with four farms per mile on each side of the road, the cost, if levied on a frontage basis, would be twice as great to the farmer as to the owner of a 40-foot city lot.

As a matter of self-interest, due to the benefits which good roads bring to a city, it is clearly a matter in which the cities of the province should heartily co-operate with the province. There is no industry which cities can bonus with so much advantage to themselves as farming. Good roads increase the produce, the saleable produce, from the farms, all of which adds to the prosperity of the city.

Under the systems of taxation in vogue in the United States, a much larger proportion of the cost of main highways is met by the cities than is being considered in this province. The maximum rate to be levied upon a city for those main arteries is restricted to one-half mill, and the county roads to be designated as "suburban" under the Act, would necessarily be restricted to such mileage as could be adequately improved with the expenditure becoming available through the combined contributions of the city, county and province.

The mileage of radiating roads to which each city should contribute will depend somewhat on local conditions. Consideration may be given to the local trade traffic entering the city; or to points of local interest close to the city; or to an area approximately that required to maintain the city with local farm produce. It is estimated that one square mile, as commonly farmed in Ontario, will support a population of about 300 persons; from which the radius of the supporting area may be estimated. Broadly, it would appear feasible to require the smaller cities to give proportionate support to about six miles of road for each mile of radius of supporting area; or on another basis, two miles to each million of assessment.

The Ontario Highways Act came into effect in January of last year, and there is considerable negotiation to be carried out in order to effect organization in all cases.

The counties in which suburban roads have been settled are York, in which Toronto contributes to the entire county road system, with a special grant of $250,000 to the Toronto-Hamilton Highway; Frontenac, in which Kingston contributes to approximately 60 miles of road; Waterloo, in which Galt contributes to 25 miles, and Kitchener to 12 miles; Essex, in which Walkerville has contributed to about 8 miles (negotiations are now in progress with Windsor). Hamilton has contributed $50,000 to the Toronto-Hamilton Highway, and negotiations are in progress with the county with respect to other suburban roads.

Department of Public Highways.—The road organization of Southern Ontario is vested in the Department of Public Highways, under the Minister of Public Works and Highways, and is in charge of a deputy minister, chief engineer, and staff. The duties of the department have a considerable range, including:

The administration of the Highway Improvement and Ontario Highways Acts, which provide for subsidies to county and main roads.

The administration of the Motor Vehicles Act, including the issuance of permits for motor vehicles, licenses for chauffeurs, etc.

The administration of the provisions of the Municipal Act with respect to plans and specifications for steel and concrete bridges.

Consultation with town, city and township councils with respect to road and street improvement.

The construction of model and experimental roads.

Educational measures such as the publication of reports and bulletins, addressing public meetings, and the instruction of county road superintendents.

Miscellaneous matters such as traffic census, the testing of road materials, road surveys and estimates.

Three-fold Classification.—It will be seen that the general trend of recent road legislation in Ontario has been toward a three-fold classification, so desirable for management and distribution of cost, and which is being evolved in the following manner:

(1) Local or Township Roads, each carrying the traffic or little more than the traffic which is created by the farms adjoining the road; such roads to be controlled by and at the expense of township councils under a township superintendent.

(2) Leading Market or County Roads, the roads radiating from local market or shipping points, which carry a considerable accumulation of traffic; such roads to be controlled by, and to be at the expense of, county councils and cities, aided by a provincial subsidy.

(3) Main Roads between important cities and other terminal points, under the control of the Provincial Department of Public Highways.

The Imperial Munitions Board and the United States Shipping Board have been in consultation recently with regard to co-operation in the production of wooden ships in Canada and the United States. Standardized types of vessels have been agreed upon, and there will be a common schedule of prices and contracts. Arrangements are now being made to have a considerable number of wooden ships for ocean transportation built on the Pacific coast. In Canada, R. P. Butchart, of Victoria, will take charge of the business organization of the industry for the Imperial Munitions Board.

Following two years of reaction and shrinking traffics the railways of Canada established new high records in the statistical year ended June 30th last, according to the annual statement of the Comptroller of Statistics. In the 12 months 1,852 miles of new lines were brought into operation, making the total in Canada 37,434. In addition a considerable proportion of 3,150 miles, classified as under construction, was really in operation by permission of the Railway Commission. Railway capital was increased during the year by the issue of $468,387 in stocks and $17,598,499 in bonds, bringing the total up to $1,893,877,819. In addition, there was a further liability of $81,481,504. The Dominion Government was operating 4,178 miles of road, the capital cost of which was $306,053,937, although they had no stocks or bonds outstanding. Railways received from the Dominion Government in the statistical year cash subsidies amounting to $1,240,435, making the total of such aid given by the Dominion, the Provinces and the municipalities $240,062,359. Many high records were established in 1915-16 for freight and passenger traffic. The number of passengers carried was 49,027,671 and the quantity of freight 109,059,088 tons, an increase over the previous 12 months of 2,705,636 passengers and 22,454,255 tons of freight. Gross earnings in 1915-16 amounted to $263,527,157, as compared with $199,843,072, and operating expenses to $180,542,259, as against $147,731,099 in the previous year. The number of railway employees in the country increased from 124,142 in 1915 to 144,770 in 1916, and their remuneration from $90,215,727 to $104,300,647.

OPERATION OF THE ONTARIO HYDRO-ELECTRIC NIAGARA SYSTEM.*

THE operation of the Niagara System for the year 1916 was attended with gratifying success. In no other year, and especially since the war commenced, have the lines and apparatus of this system been called upon for such extraordinary duty. This condition was occasioned by the rapid recovery of industry, together with the enormous development of the manufacture of war munitions in Canada.

During the months of November to April, inclusive, and from July to October, power was purchased for transformation and transmission from two, and indirectly three, sources, the supplying plants being linked together by the Commission's transforming station at Niagara Falls. On April 30th the temporary contract with the Toronto Power Company expired, and from this date until July 26th, when the first generating unit from the Canadian Niagara Power Company was connected, the total load of the Niagara System was carried by the Ontario Power Company. On August 21st a second unit at the Canadian Niagara Power Company's plant was paralleled with the first, and from this date until the end of October the amount of power available from this company amounted to approximately 25,000 horse-power. As these generating stations were operating at maximum capacity, extreme caution was necessarily exercised in the operation of the system in order to preserve equilibrium at all times.

Electrical storms during the past year were much more frequent and severe than in previous years. The Niagara System was subjected to these storms on sixty different days. On eight days these storms traversed practically the entire system, and were particularly severe. The balance of the storms traversed only portions of the system, mainly in the Niagara Peninsula, Preston, Stratford and Chatham districts, and were more or less severe. No total system interruption occurred from lightning causes during the summer, and when it is considered that the Commission has in operation approximately 1,200 miles of high and low tension lines overstretching a strip of Ontario approximately 215 miles long and averaging 60 miles wide, all lines being subjected to the accumulation of electrical discharges, which must be dissipated by passage to ground, the efficiency of the protective apparatus is strikingly evident.

Work of a special nature carried out by the Line Maintenance Department, and required by reason of the rapid increase of load, included the erection of a temporary 12,000 volt double circuit pole line of No. 4 0 copper conductor between the power house of the Canadian Niagara Company's station and a point (on the present line between the Hydro and Toronto Power Company transforming stations) approximately 1,800 feet south of the Commission's station. Both circuits of this pole line are still in service pending the installation of the balance of the underground feeders to the Canadian Niagara Power Company's plant.

The erection of a fourth No. 4 0 copper, three-phase circuit 15.5 miles long, on the 46,000 volt tower line between Niagara Falls and Welland was completed and placed in operation.

The single or three-phase circuit of No. 2 aluminum between the high tension station and the municipal

*From the ninth annual report of the Ontario Hydro-Electric Power Commission.

station at Dundas was replaced with a double circuit of No. 4 copper.

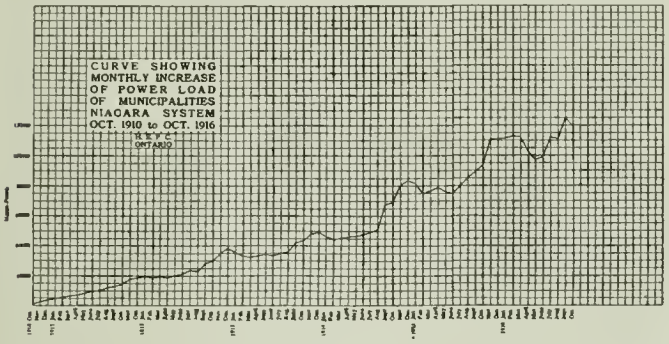
The wood pole line from the Dundas high tension to the city of Hamilton, which was replaced by a steel tower line during the summer of 1915, was taken down.

Short stretches of single circuit 26,400 volt lines were constructed to supply the Lake Erie and Northern Railway Company's sub-stations at Brantford and Simcoe from the outgoing circuits of Brant high tension station.

In view of the many new customers added in the Stratford district, and the length of line necessary to serve them, it has been decided to raise the transmission voltage in this district from 13,200 to 26,400. To this end considerable rearranging of the power and telephone lines was carried out in preparation for this change.

Some relocation of the 13,200 volt line feeding the Mimico distribution station from the Cooksville high tension station was necessary, due to the construction of the Toronto-Hamilton Highway. The portion of line affected extended from Port Credit to New Toronto.

A twenty-five "pair" lead-covered telephone cable, approximately 13,500 feet long, was installed between the high tension station and the Commission's new office building at Toronto. The cable was laid in the Toronto



Hydro-Electric System duct line to the corner of Queen and William Streets and from thence to the office building on the concrete poles.

Few failures of any of the electrical or mechanical equipment of the high tension stations occurred during the year. As the Commission, in common with other enterprises in Canada, was severely handicapped in obtaining delivery on additional apparatus required to cope with the abnormal demand for power, the present equipment in some of the stations was subjected to overload for short periods, but without any depreciating results. The difficulty, mentioned above, was partially met by the transfer, where feasible, of transformers from one station to another.

Considerable time has been spent in perfecting refinements in connection with the measurement of power, which has been to a great extent apparently considered unnecessary heretofore by the majority of other organizations. These refinements extend from the periodic comparison of the Commission's portable standard meters with ultimate standards to the determination of the characteristics of instrument transformers of various types.

A concrete roadway, approximately 300 feet long and 6 inches thick, was laid across the flats at Preston, from the fair grounds to the Commission's property. It is expected that this roadway will be unaffected by the heavy spring floods in this vicinity, which previously rendered impassable the original gravel-topped roadway.

An increase was made in the supply of cooling water for this station by the sinking of a well just outside the station and the installation of a deep-well pump for pumping the water directly into the cooling system. The supply originally obtained from the small creek in the flats had latterly become inadequate.

The plotted curve shows the monthly increase in the load supplied on the Niagara System from October, 1910, to October, 1916.

CIVIC ENGINEERING IN VICTORIA, B.C.

CITY Engineer C. H. Rust, of Victoria, B.C., has submitted to the city's aldermen the annual report covering the past year's work of his department. Following are some abstracts from the report:—

The expenditure, owing to the war, has been very much below that of the previous year, the total being $372,155.15, divided as follows:—

Local improvements, $29,501; sewer loan construction, $61,633; maintenance of streets, bridges and sidewalks, $61,725; street cleaning, $46,348; garbage collection, $40,540; waterworks, $45,518; parks, $14,547; sundries, $64,222; removing snow, $8,117.

Number of square yards of streets oiled during year, 537,110.

Number of cubic yards of garbage collected during year, 25,581.

Total mileage of concrete sidewalks	132.4	miles
" " " boulevards	65.2	"
" " " sewers	120	"
" " " water mains	134.25	"
" " " surface drains	83.21	"
" " " asphalt pavements	55.0	"
" " " wood block pavements	3.5	"
" " " concrete pavements	1.1	"
" " " macadam pavements	11.0	"
" " " tar macadam pavements	1.0	"
" " " vitrified brick	0.6	"
" " " macadam pavements	11.0	"
" " " unpaved streets	78.0	"
Total length of B.C. Electric Railway Company's pole lines carrying lighting and power cables, approximately	125	"
Total length of B.C. Electric Railway street railway lines	20	"
Total length of B.C. Telephone Company's pole lines, approximately	100	"
Underground main conduits on streets	8	"

The average costs for labor and material on sidewalk and road construction during the year were as follows:—

Grading, per cubic yard (earth)	36c. to $0.91
Curb and gutters, per lineal foot	.42
Concrete base 5 ins. thick	.82
Macadam, per square yard 7 ins. thick	.65
Sheet asphalt, 2 ins. thick, per square yard	.48
Sheet asphalt, 2 ins. top, 1 in. binder, per sq. yd.	.61
Concrete pavement, 7 ins. thick, per square yard	1.30
Concrete retaining walls, per cubic yard	6.15
Sidewalks, per square foot	.11

These amounts do not include any overhead charges.

The cost of maintaining our macadam roadways has been low, owing to the treatment of the surface with heavy oil.

Considerable relief has been given to the residential sections by the construction of macadam trails on unimproved streets.

During the year the Streets Committee decided that untreated wood blocks manufactured by local firms should be used in place of procuring treated blocks from Vancouver. This was carried out against the engineer's advice, and it remains to be seen how the life-time of these blocks will compare with that of the treated ones.

The total expenditure for street cleaning during the year amounted to $46,134.43. All cleaning was carried out by hand-brooms, pick-up carts and cans. The average cost was $0.116 per 1,000 square yards daily. The cost last year was $0.134 per thousand square yards. The business districts were covered more frequently.

During the past year 537,110 square yards of street surfaces were oiled, of which 27,326 square yards were given a second treatment. The unit cost per square yard was $0.012. The total expenditure was $6,438.98, divided as follows:—

Preparing street for oiling .....$1.10 per 1,000 sq. yds.
Oiling street, including cost of oil 7.21 per 1,000 sq. yds.
Sanding streets after oiling, including sand ..... 3.92 per 1,000 sq. yds.

The cost last year was $0.0123 per square yard.

Not only has the oiling of the streets practically stopped the dust nuisance which formerly existed in this city, but has added very much to the life-time of the macadam surface. These streets have now been oiled for the past four years and the surface has become in many instances practically impervious, thus prolonging the life-time.

During the winter of 1915-1916 some damage was done to Ross Bay sea-wall by southeasterly storms. To prevent a recurrence of this damage a contract was awarded for the driving of sheet piles at the toe of the wall. 1,370 feet were thus treated, and opposite 450 ft. of this wall heavy rock was deposited. The piling was carried out by Watson, Hall & Huntley, of Victoria, and $4,130.50 was expended on this work, which has not yet been completed.

The north-west main sewer is now completed, 2,071 feet having been laid during the year. The entire work has been carried out by day labor. 7,449 feet of the sewer was in tunnel, of which 6,390 lineal feet was in rock, at an average depth below the surface of 44 feet. The work also included the laying of a submerged 36-inch steel pipe for the outfall and inverted siphons under Selkirk water, a distance of 491 feet.

The labor cost of tunnel work during the first couple of months was $8.75 per lineal foot of tunnel. This was steadily reduced until during the last two months it was $4.75 per lineal foot. The estimated cost of the entire work as prepared by the engineers of the three interested municipalities, was $365,223, and the total cost of the work has been $298,853.

The total length of the sewer is 16,578 lineal feet, or 3.139 miles.

This completes the main part of the north-west sewer. Two branch mains, however, are now in progress. The average cost for open cut work for an average depth of 16 feet for the whole north-west main sewer was as follows (for labor only):—

Rock, for labor only, $3.65 per cu. yd.; hardpan, $1.69 per cu. yd.; dirt, 89c. per cu. yd.; backfill, 22c. per cu. yd.

The average cost per lineal foot for similar tunnel work was:—

Labor, excavating only, $8.50; all labor, $12.98; 36-in. sewer complete, $24.92.

Exclusive of the north-west sewer 14,467 ft., or 2.74 miles of sanitary sewers were constructed, bringing the total mileage in Victoria up to 120.

In October a number of leaks developed in the Sooke Lake conduit line. This occurred after a sudden change in the temperature, which during the day time was 60 degrees in the shade, and as low as 20 degrees at night. When the temperature rose and averaged about 40 degrees, the majority of these leaks stopped. The largest leaks, however, were on the big siphon at the east branch of the Sooke River, and were caused primarily by the settlement of one of the concrete bents. We propose during the coming year to take steps to prevent, if possible, a recurrence of this trouble.

During the year engineers, representing the Department of Agriculture of the U.S. Government, made a series of tests on the concrete flowline for the purpose of obtaining accurate records of the flow of water in concrete pipes.

The average amount of water passing through the meter at Humpback Reservoir is 5,050,741 Imp. gallons daily, equal to 100 gallons per head of population supplied, whilst the average amount actually sold as recorded by the various meters, including the water supplied to Saanich, Oak Bay and the Empress Hotel, averages 2,200,000 Imp. gallons daily, or an average per capita of 40 gallons.

Making liberal allowance for the leakage on mains, the use of water for sewer flushing, water for fire purposes and for boulevards, there is still about 1,000,000 gallons daily not accounted for. Fortunately we have an ample supply of water and the city is put to no expense for pumping or filtration. We are now taking steps to ascertain, if possible, where this loss occurs.

MARCH RAILWAY RETURNS.

Comparisons of the Canadian Pacific Railway's returns of March gross and net earnings during the past eight years, are given in the following table:—

March.	Gross.	Net.
1917	$11,846,542	$3,937,317
1916	10,380,981	3,421,330
1915	7,852,989	2,973,014
1914	9,447,461	3,099,239
1913	11,111,892	3,855,416
1912	10,519,319	3,718,401
1911	8,800,640	3,156,566
1910	7,796,337	2,711,173

The Grand Trunk Railway's net returns for the first quarter of 1917 are as follows:—

January	$691,763	inc.	$135,866	24.44%
February	241,796	dec.	304,556	55.7 %
March	948,299	inc.	62,034	7 %

Canadian Northern Railway's statement of earnings and expenses for March is as follows:—

	1917.	1916.	Increase.
Total gross earnings ..	$ 3,273,200	$ 2,607,000	+ $ 666,200
Operating expenses	2,655,100	2,240,600	+ 414,500
Net earnings	618,100	366,400	+ 251,700
Aggregate gross earnings from July 1st	30,095,900	24,134,600	+ 5,961,300
Aggregate net earnings from July 1st	7,504,500	6,275,700	+ 1,228,800

Letters to the Editor

Canadian Engineers.

Sir,—During the last few years considerable has been said and written by members of the Canadian Society of Civil Engineers regarding the status of the engineering profession in Canada. Mr. W. F. Tye, in his address at Ottawa on March 29th last referred to the engineer's standing and gave some advice for improving our status before the public and to demand a greater share than now given on government engineering commissions. It is only too true that Canadian engineers are being too often overlooked by our governments when they make appointments to important public engineering works and commissions. Most emphatically it can be said that there is no valid reason whatsoever for any Canadian government to go outside of Canada for engineers. There are no problems or projects in Canada which cannot be more capably handled by Canadian engineers than by engineers from other countries. We are at least on a par with them as far as education and abilities are concerned, and we have the advantage that we are in our own country and hence undoubtedly more intimately acquainted with all its conditions. The preference often shown to outsiders is certainly somewhat inexplicable.

It is, however, difficult, in fact impossible, for the most of our engineers to participate in the actual government of the country by becoming members of parliament and senators. Lawyers, doctors, farmers and merchants have always a fixed place of residence. The avocation of the engineer does not render his life so fortunate as to allow him a permanent place of abode, nor does the fact that he is an employee allow him time or opportunity to participate in the political affairs of the country. Only the comparatively small number of engineers who are in private practice are justified in aspiring to become members of parliament or senators. So it appears that the bane of the engineering profession is its non-independence and the nomadic mode of life to which its members are compelled to accommodate themselves. I have no suggestions of improvements to make at present, but would think that herein lies an opportunity for our society to become more useful to its members, namely, by evolving a new basis for the profession whereby its members could more easily situate themselves so that they could take a more active part in the public affairs of the country.

A. J. MACDONALD, A.M.Can.Soc.C.E.

St. Irénée, Que., April 16, 1917.

Inspecting Engineers.

Sir,—In these days of the great world war, an army of inspectors of every classification has grown in our midst. Are they to stay professionally, and be received into the engineering world? There are two classes of inspectors,—those that make a profession of inspection, and the second-year student with the influential pull and a library of books which he believes will direct him in the practical works of engineering. The latter class has belittled the inspector's position of to-day.

What are the duties of the inspector? He is engaged to carry out the duties of the clerk of works, and must have a good working knowledge of plans and a technical training, and must be essentially practical in all things to obtain results to the satisfaction of all concerned.

The leading architects of Canada all have staffs of inspectors, with one man as chief inspector who goes over all work for its final acceptance, but receives little, if any, reimbursement for his discretion.

Do engineers realize that when they call for the services of an inspector and place him in charge, that all the responsibility is in reality on the inspector? Should any bad work or oversight in construction arise at the finish, he is dismissed, but when all is O.K. then you do not see Mr. Inspector or hear of him.

In your issue of April 19th you have an article by Mr. C. A. Mullen. This gentleman states that inspection and testing is a sound investment. I fully agree from every point of view except one, and that is,—it is a very poor investment for the inspector. He is underpaid, and he must be honest. Keep him honest, for his services are essential.

G. H. LOVETT,
Inspecting Engineer.

Quebec, P.Q., April 23rd, 1917.

[NOTE:—The above letter is unique in that it represents the thoughts of one of a class of men who seldom express their viewpoints in print but from whom we would like to hear oftener. Mr. Lovett's plea for better treatment of inspectors—particularly chief inspectors—will find fertile ground among engineers, as the latter realize how important is intelligent inspection in all contracts.—EDITOR.]

Municipal Consulting Engineers.

Sir,—I am sorry that in your editorial of March 15th, 1917, you attributed to my article on "Consulting Engineers' Fees" a meaning it was not intended to, and does not, convey.

You say that, stripped of excess verbiage, I assert that consulting engineers *purposely* underestimate. I said no such thing, but I did state that on the percentage system a temptation is placed before the engineer to underestimate. My article further stated that in many cases which have come before me, the preliminary estimate bore little relation to the final cost. You say it is hardly likely that I can give chapter and verse in substantiation, which is precisely what I am able to do in a good many instances. I am prepared to give, and to substantiate, many cases of underestimating, in which, as I stated in my article, the preliminary estimate bears little relation to the final cost, but I do not think you should suggest the Canadian Society of Civil Engineers as the tribunal, as however fair-minded its members may be, it could scarcely be called an impartial tribunal. Probably the Canadian Union of Municipalities could better appoint a tribunal to consider the matter, and if you wish it carried further, the following is one of the cases I have in mind.

In the town of "X" a well-known Eastern consulting engineer prepared a preliminary estimate for a waterworks system, which was to include delivery to the town and the laying of mains, to cost, as per the estimate, say, $100,000. The report continued: "Laterals and house connections will, of course, be paid for by the properties served." In other words, this latter sentence would lead anyone not familiar with municipal finance to believe there was no need to borrow money for laterals and house connections, and that $100,000 was all the capital required. What was the result? The town, having endorsed the preliminary estimate, had to go on, and spent

more than twice $100,000 in completing the work covered by the preliminary report. This year the Local Government Board held an enquiry to see whether this town could pay its fixed charges or not, and every ratepayer interrogated said that the preliminary report had misled him as to the cost of the proposed works.

That "mild amusement" is not the effect on the engineering profession, is evident from an article appearing in a Western journal this month, by a well-known consulting engineer, Mr. T. Aird Murray, M.Can.Soc.C.E. He says: "The method of charging upon a percentage basis has often been criticized both by engineers themselves and others, but no other satisfactory method has been formulated. The danger in engineers underestimating the value of work chiefly exists at the time when the preliminary report and estimate are prepared, and this is more so when two or more engineers may be competing against one another for the work."

Again, in the "Engineering Record" of March 24th, 1917, Sir Maurice Fitz-Maurice, in his inaugural address as president of the Institution of Civil Engineers, is reported to have asked the question, "Are engineers too optimistic in designing their work, and in their estimates of time and cost?" Answering the question, he says that engineers must plead guilty to the charge sometimes at least. Further, I believe that an American engineering weekly recently adversely criticized the percentage system. What further justification do I need?

I also perused, with interest, another letter to you from Mr. Underwood, of Saskatoon, criticizing my article. I wonder if Mr. Underwood ever heard of the case of a town in the southern part of this province, for which an engineer he may wot of, estimated the cost of a waterworks system at a certain figure, and who, when the bids for the work were found to be in excess of his estimate, and that the money to proceed with the work would not be forthcoming, pared his estimates and received bids within the amount available, after assuring all concerned that his first figure was an overestimate for the work proposed.

You overlook entirely the other phase of my article. In it I blame councils for the lax manner in which they enter into arrangements with their engineers, and I attribute many existing municipal financial embarrassments to this cause. One case came within my notice where the only document relating to the engagement of an engineer was a telegram from him stating his terms. And this for work estimated at over half a million, and as a result, when the final settlement came to be made, the engineer did not apparently know to 25 per cent. the exact cost of the work, having merely taken the annual financial statement as a basis for commission, so that he might be claiming on his own fees, legal fees, debenture discount, and all sorts of other things.

I still contend that a fixed sum for the work covered by the original estimate is the fairest all round, and of course councils would expect to pay extra for any additional work performed by their instructions. Can you tell me any good reason why an engineer should receive $600 extra commission if, between the date of the report and the acceptance of the tender for cast-iron piping and specials estimated to cost $60,000, the market should suddenly soar, so that the lowest tender was $72,000; or why, on the reverse, if the market should drop so that the material could be bought for $48,000, the engineer's commission should be reduced by $600?

There is a provision in the Municipal Acts of this province, that where special work is performed for municipalities by members of my profession, the bill can be submitted to the government for approval before payment. My profession sees no objection in this. Would the engineering profession be satisfied with a similar provision?

Happily, nowadays in Saskatchewan, capital expenditure by municipalities is under very strict control, and we do not think we shall have the same trouble in the future from engineers' and councils' extravagance that we have had in the past. Other provinces please note.

Now, in concluding an article already too long, may I say that I am proud my father was an English civil engineer, my brother is, or was, president of a society of civil engineers in China, and that I and all my brothers are, or have been, municipal men. It is not likely, therefore, that I should make an "unjustified attack" upon a profession of which my nearest and dearest relatives are members, unless I felt that an evil existed for which my municipal experience, not merely in my own province, seemed to fit me to draw attention. It is only natural that you, as the mouthpiece of the engineering profession, should to some extent resent my article, but if you are typical of your profession, you are a sportsman and will bear no ill will.

O. J. GODFREY, F.C.A.

Indian Head, Sask., April 23rd, 1917.

[NOTE:—No ill will whatever, Mr. Godfrey. Our previous editorial served an excellent purpose if it did nothing more than to bring forth this interesting and instructive letter from you. Had your previous article been as gently worded as your present letter, our resentment would have been milder.

In your original article you plainly accused consulting engineers generally of succumbing to the temptation to underestimate in order to get appointments on work which would not be undertaken if correctly estimated. Yet now you disavow any intention of saying that engineers purposely underestimate. We all admit the possible existence of the "temptation." What we objected to was your inference that engineers usually succumb to it and that you "have yet to see my first case of the actual cost of waterworks or electric light coming within the original estimate of the consulting engineer."

Also, how about your statement that "with due deference to the engineering profession, I make bold to say that if a limit had been placed on the engineer's fee for the completed work, much of the over-expenditure would not have occurred"? Was that not accusing engineers of dishonesty by inferring that they allowed "over-expenditures" in order to collect their percentages on same? Your meaning was certainly clear, because you elaborated on the point in the following manner:—

"In other words, if on an estimated cost of, say, $100,000 the council engaged the engineer to supervise the work proposed by his plan, irrespective of cost, at 5 per cent. on expenditures, the total fee not to exceed $5,000, I feel sure that the work would be done at much nearer the amount of the original estimate than has been the case in the past."

How does this agree with your illustration of the cast-iron pipe purchase? Supposing that the market soared after the date of the engineer's report, and the pipe cost $600 too much, would the engineer be supposed to "skimp" other parts of the work to make up that $600?

We recognize your standing in the municipal field, and it was for that reason that we thought your article sufficiently important to require editorial comment. Had your remarks come from a municipal accountant of less prestige and experience, probably no attention would have been given to them.

Mr. Murray's article, Sir Maurice Fitz-Maurice's opinion, and the views of the American engineering journal, to all of which you refer, may be absolutely correct. We never expressed any opinion differing from them. We took exception merely to your reflections upon the integrity of the engineering profession, and held no brief for the percentage system.—EDITOR.]

WELLAND CANAL WORK SHUT DOWN.

Work on the Welland Ship Canal was completely closed down May 2nd, 1917, when the services of all the engineering staff were dispensed with, including those of J. L. Weller, engineer in charge, to whose initiative the building of this great work is due. The contracts for four sections, comprising about eleven miles of canal and all of the seven lift locks and amounting to about $25,000,000, are about half completed.

The contractors were instructed last January to close down all their works for a period of one year and at the end of that time a further period of closing down would probably be specified. They are not allowed to sell their plant or remove it from the work without special permission from the department.

Chief Engineer Weller has been building and operating canals for 34 years, and having made a special study of this subject, has been able to effect great improvements in the Canadian canal system. He is responsible for very many of the better features of design now in use on canals.

MANITOBA BRANCH, CAN. SOC. C.E.

A meeting of the Electrical Section of the Manitoba Branch of the Canadian Society of Civil Engineers was held in the University Building, Winnipeg, on Wednesday evening, May 9th, when two papers were read. H. McConkey described the Morkrum Duplex Telegraph Printer, a wonderfully intricate device that increases tremendously the speed at which telegraph messages can be received. The machine responds to the incoming message by perforating a continuous paper tape and this tape, later run through a special mechanism somewhat resembling a typewriter, automatically types out the message. Mr. McConkey had the complete device on exhibition and an operator gave demonstrations of its speed and accuracy. F. S. Griffin then read a highly technical paper on an efficiency test on a large water-wheel connected with an electric generator. There was a good attendance. The president, W. G. Chase, was in the chair.

KITCHENER'S NEW ENGINEER.

The city council of Kitchener, Ontario, last week voted by 8 to 7 in favor of the appointment of Mr. B. E. Michel as city engineer at a salary of $1,800 to fill the position which was still being occupied by City Engineer Johnston, who has been receiving a salary of $2,250. No charges of incompetency have been preferred against Mr. Johnston.

A report received by the finance committee from Mr. Willis Chipman, consulting engineer, Toronto, who drew the plans for the new sewer beds, stated that some of the work had suffered from the frost, but apparently put the blame on the contractor. He declared $1,000 will remedy the walls which are damaged.

MONTREAL AQUEDUCT REPORT.

Covering forty-three typewritten pages, the report of H. E. Vautelet, A. St. Laurent and J. B. McRae, on the Montreal Aqueduct was presented last week to the Montreal city controllers. The report was referred back to Mr. Vautelet for translation into French before being given out for publication. It is understood, however, that the recommendations are as follows:—

"1st. That the south wall of the aqueduct be at once extended to the rock section and that the west earth section be completed with paving where needed, as this should be done for all enterprises.

"2nd. That no work be done on the rock section or on the east earth section, until the final scheme is decided upon. This also applies to the tailrace.

"3rd. That you immediately ask the several companies furnishing electric power in the city, for firm bids on power. Carefully worked out specifications should be furnished to the power companies setting forth the exact conditions of the service required.

"Prices should be, at the same time, obtained from the contractor for all changes and additions to the present contract.

"As soon as this is done (and it should be done in a couple of weeks) you shall be able to come to a decision with full knowledge of the costs of operation of all schemes.

"As all our figures will be in the hands of your chief engineer, he will be able to place before you the exact cost of each scheme.

"In the meantime, studies should be started and designs made for the proposed electric motor-driven pumping station. This station should be designed to pump the output of the proposed new filter plant, which is to be 100,000,000 Imperial gallons per day. Provision should also be made for future extensions. The equipment of this station will be the same whether you generate your own electric power, or buy it. The plans for the steam standby station should also be put in hand. We have suggested that the new pumping plant be located on the south side of the aqueduct near the filters.

"This should provide a most convenient location for all piping connections. It also facilitates the connection of the steam standby to the heating system that is proposed for the filters.

"No addition or alterations to the present steam pumping plant should be made.

"The plans for the hydro-electric station may be delayed until you have come to a decision regarding the course of power.

"4th. That the lands required be secured at once, so as to prevent further delays to the work.

"5th. That the addition to the filtration works at a cost of $900,000 be proceeded with."

DOMINION HEALTH DEPARTMENT SUGGESTED.

Dr. Michael Steele, South Perth, has submitted a resolution to the Dominion Parliament calling for the organization of a separate department of government to have "supervision over all matters relating to the physical welfare of the people of the Dominion." No conflict with the provincial jurisdiction in health matters is contemplated. Hon. Martin Burrell, Minister of Agriculture, said the time would come when it would be necessary to co-ordinate all activities in regard to human health, medical research work, national health, and health as it affects international problems, as well as sanitation.

INTERNATIONAL NICKEL PLANT.

Considering the bad weather, much progress has been made on the new plant of the International Nickel Company at Port Colborne. On April 20th it was reported that with the exception of the power plant, the foundations were practically all in, the steel work on the main building was nearly completed, three of the smaller brick buildings were almost complete and with good weather and no labor troubles it is expected that the first nickel will be turned out in December of this year. The estimated cost of the completed refinery will be about $4,000,000.

The plant is situated east of the entrance to the Welland Canal and consists of 350 acres, with a frontage of about one mile on Lake Erie. Transportation facilities are good, connection being established with the Grand Trunk and the Welland Canal may be utilized for the transportation of materials if necessary.

The entire construction is in the hands of the Foundation Company, Limited, Montreal, with whom the operating and engineering departments of the nickel company are co-operating, who have employed four hundred men during the winter and have made preparation to enlarge this number to one thousand this spring.

The initial output of the refinery will be 15,000,000 pounds of refined nickel a year, but provision has been made so that the capacity can be increased to two or even four times this amount, if necessary. The operating force will be about four hundred men. The two main stacks will be 350 feet high and 12 feet across the top, the whole resting on heavy concrete bases 40 feet square. Most of the supplies for the construction have been purchased in Canada, very little being imported.

In operation, the plant will consume 100,000 tons annually of bituminous coal, coke, cordwood, fuel oil, nitre cake charcoal, silica, rock salt, soda ash, soda nitrate, sulphuric acid, fire clay and fire brick, in addition to the copper-nickel matte which will be supplied from the company's mines at Sudbury.

That every stage of nickel production should be carried out in Canada from the quarrying of the ore to the chemical and mechanical processes involved in making the scientific appliances and metal products which nickel alone can supply, is now the general conviction. This conviction is founded on the fact that roughly speaking eighty per cent. or more of the world's nickel is mined in Canada and the percentage is increasing rather than diminishing.

GRAND TRUNK'S FINANCIAL POSITION.

President E. J. Chamberlin, of the Grand Trunk System, speaking in regard to the government commission's report on the Canadian railway situation, said:—

"I have read the majority report of Sir Henry Drayton and Mr. W. M. Acworth, who with Mr. A. H. Smith president of the New York Central Company, were appointed a special commission to examine the Canadian railway situation, I have not, however, seen the report of Mr. Smith, dissenting from the views of the other commissioners.

"I am extremely surprised at some of the statements made in the report with regard to the position of the Grand Trunk Railway Company of Canada, which, with all respect to the commissioners signing the majority report, I am compelled to say are inaccurate and misleading. So far as that company is concerned, its credit at the present time is high and its financial position not at all as stated in the report.

"During the past five years the Grand Trunk has borrowed in New York for capital purposes over $15,000,000, and had it not been for the war, which created abnormal conditions, further capital would have been procured and expended if prices had been satisfactory and deliveries could have been obtained.

"In view of statements contained in the report, and calculated to impair the credit of the company, I think it only just to the holders of Grand Trunk securities that they should be assured of the absolute safety of their investment.

"At a later date a full statement with regard to the company's position will be made."

TO DIRECT STEEL SHIPBUILDING.

Mr. W. I. Gear, of the Robert Reford Company, Montreal, has been appointed to take charge, under the Imperial Munitions Board, of steel merchant ship construction in Canada for the British government. Mr. Gear will establish an office at Ottawa and assume his new duties. It is understood that Sir Robert Borden on his return to Canada will at once take up the question of further stimulating shipbuilding in Canada.

MORE PAPER MILL ACTIVITIES.

The paper plant at Port Mellon, Howe Sound, established some years ago, but which has been idle for a long time, is being altered for the manufacture of kraft paper. The Rainy River Pulp and Paper Company has been organized by a syndicate of New York capitalists, headed by Mr. Robert Sweeny. Kraft paper will also be manufactured by the Pacific Mills Company, Limited, which has nearly completed its plant at Ocean Falls. A second and larger unit is now under construction directly across Link River from the present plant.

RAILWAY MATERIAL FOR FRANCE.

Another request for railway materials to construct roads behind the lines of the armies in France for use in the military operations on that front has been received by the Canadian government from the British authorities. This time enough rails to lay 300 miles of railway are required. These will be secured by dismantling a stretch of about 200 miles of the Grand Trunk Pacific Railway where it parallels the Canadian Northern west of Edmonton.

BRITAIN MAY BUILD AT TORONTO EXHIBITION.

The Dominions Royal Commission have recommended in their fifth and final reports to the imperial government that that government should erect a building at the Canadian National Exhibition, Toronto. "We think," says the report, "that the governments of the other dominions might well follow suit in this respect, and that similar encouragement might be given to National Exhibitions in other parts of the Empire as soon as they have, by results, justified their existence in the same manner as has that at Toronto."

WINNIPEG ELECTRIC RY. CO.'S EARNINGS.

The annual report of the Winnipeg Electric Railway, just issued, shows a net surplus of $445,251 for the year's operations, equal to 4.9 per cent. on the capital stock, compared with 5.5 per cent. the previous year. The gross earnings for 1916 were $3,311,169, compared with $3,663,895 for 1915 and $4,101,302 for 1914. Operating expenses were $1,930,041, compared with $2,332,158 for 1915 and $2,416,209 for 1914.

ENGINEERS' CLUB, PETERBOROUGH.

Mr. J. A. Shaw, of Montreal, chief electrical engineer of the C.P.R., delivered an illustrated lecture on "The Electrification of Steam Railways," before the Engineers' Club of Peterborough on Friday evening, May 11th. The lecture was preceded by a dinner at the Oriental Hotel.

R.U.V. CO. APPOINTS CANADIAN AGENTS.

The R. U. V. Co., 50 Broad St., New York City, announces that the Northern Electric Co., of Montreal, will hereafter have exclusive Canadian selling rights for Ultra-Violet-Ray Water Sterilizers. These sterilizers have been installed for purifying water for municipalities, industrial institutions, residences, swimming pools, bottlers, breweries, etc.

Editorial

PARLIAMENT AND THE TRUSTEES.

One of Mr. A. H. Smith's chief objections to the report of his two colleagues on the Railway Inquiry Commission, is that "there is no means by which one parliament can bind its successors to a given policy, especially in so simple a matter as changing the organization of a government board." *The Canadian Engineer* does not believe that any parliament would dare to change the organization of such a board appointed under present circumstances.

Should the Drayton-Acworth report be approved by parliament, and the board of trustees formed along the lines suggested, no government could afford to throw a political monkey-wrench into the wheels. Appeal to the people by the opposition or by the trustees themselves, would be instantaneously effective, and that government would suddenly cease.

Another great safeguard is the fact that the five members are to hold the entire stock of the Dominion Railway Co., all shares being registered in their own names jointly with that of the Minister of Finance, and that they are to hold it in trust for the Dominion and not transferable to any other person excepting a successor in office. And the latter must be another trustee duly elected according to the provisions of the charter of the company. The Drayton-Acworth system of organization of the board of trustees appears to be ingenious. It is not infallible nor parliament-proof, but at all times public opinion must be depended upon to check parliament. One might argue that parliament would hand over the Dominion Railway Co. and all its assets to Sir Wm. Mackenzie, or some other person, free of charge.

Public opinion, properly roused, is a greater safeguard than any constitution, by-laws or Parliamentary Acts. We believe that Mr. Smith, in his objection to the majority report of the commission, has failed to rely sufficiently upon the force of public opinion.

MACKENZIE AND MANN.

Many people have labored for years under the impression that Sir William Mackenzie and Sir Donald Mann, or the firm of Mackenzie, Mann & Co., Limited, made fat cash profits on their contracts for the construction of the Canadian Northern Railway. To those people some of the revelations of the Railway Inquiry Commission will be a pleasant surprise.

In the Drayton-Acworth report it is made clear that all charges of misappropriation of railway funds by Mackenzie and Mann are entirely unfounded. Mr. Hanna, the vice-president of the railway, and Mr. Mitchell, its comptroller, both gave evidence on oath before the commissioners, both stating that neither the contracting firm, nor Mackenzie nor Mann personally, ever made any profit on their work for the Canadian Northern Railway other than certain "fully paid" common stock. No contractor's commissions were deducted. All work was turned into the railway company at cost and there was no allowance for the main contractors. It was stated that the subcontractors were not affiliated interests. Mr. Hanna swore that neither Sir William Mackenzie nor Sir Donald Mann drew any salary and that neither of them was ever on a Canadian Northern voucher list, nor on a voucher list of any of the Canadian Northern subsidiaries, to the extent of a dollar.

The report says, "The result of our inquiries leads us to the conviction that both Sir William Mackenzie and Sir Donald Mann had a firm belief in the ultimate success of their undertaking and in their own ability to carry it to a successful conclusion." On another page the report says that the Canadian Northern Railway was skilfully financed and economically constructed, the big mistake consisting entirely in the road's too rapid extension out of its original profitable field in the prairie provinces.

To sum up, it appears that Mackenzie, Mann & Co., Limited, turned in $204,000,000 worth of work to the Canadian Northern Railway at exact cost, taking as sole profit on same, some portion of the $100,000,000 common stock of the railway which they now hold. The remainder of this common stock was probably taken for other services to the road. It is evident that in any settlement of the railway problem, the Canadian Northern common stock should not be treated as mere "water." The stock was not paid for in cash, but it represents services of undoubted value,—whether to the full extent of a hundred million dollars or not is debatable,—but certainly some large value which, in justice to the builders of the road, should be treated as partially ranking with the system's other securities.

RAILWAYS AND THE PUBLIC DEBT.

In referring to the Drayton-Acworth report, Mr. A. H. Smith says in his minority report: "Their plan would add about a billion dollars to the direct debt of Canada." We cannot see how Mr. Smith arrives at this conclusion. It is even possible that the Drayton-Acworth scheme might more nearly result in deducting a billion dollars from the *real* national debt of Canada.

What Mr. Smith, no doubt, refers to is that Canada has invested $968,451,737 in railways, and he infers that if the country were to take over direct liability for all these roads, it would add that sum to the country's debt. As a matter of fact, the country has already expended, and now has or has had included in its debt, the sum of $442,906,297 out of this $968,451,737. This sum of $442,906,297 is made up of $157,294,329 subsidies to the C.N.R., G.T.P., G.T.R. and C.P.R., and $285,611,968 cost of roads now owned outright by the government. Another considerable portion of this $968,451,737—a sum amounting to $158,189,933—is the result of the sale of lands given by the government, and while perhaps properly included in the total of public aid to railways, this cannot be properly considered a part of the debt of such railways. As a matter of fact, most of this land would have been practically worthless had there not been built the railways to which the land was given.

The only real increase of the national debt would come in the direct assumption of the outstanding loans and guarantees to existing private corporations, plus that portion of the new capital expenditure of the Dominion

Railway Co. which would be raised on the credit of the government's railway properties as they now exist.

The total of the loans and guarantees outstanding is $367,355,507. Assuming that initial capital expenditure to the extent of $132,644,493 were to be required by the Dominion Railway Co., the amount really added to the direct liabilities of Canada would be half a billion dollars,—not a billion dollars. But is not the $367,355,507 loans and guarantees, as at present existing, really and practically a part of the national debt, even though it does not appear as such in the national balance sheet? Because, under existing conditions, would not the government be required to make good on most of its guarantees? or will it have reasonable chance of collecting its railway loans, or even interest upon them, if some radical change is not made in the handling of the assets that have been created by those obligations? If the Dominion Railway Co., as outlined by the Drayton-Acworth report, can pay its own way, might it not be better for the government to have the half billion dollars added to its direct debt and at the same time acquire assets fully corresponding to that debt—assets to be so managed as to earn interest on the debt—than to continue as at present?

PERSONAL.

Major E. G. M. CAPE, president of E. G. M. Cape, Limited, contractors, Montreal, has been reported wounded in the recent heavy fighting following the battle of Arras. The most definite information is that he is on sick leave in London. Major Cape raised one of the first units that left Montreal, which was known as Cape's Battery, Heavy Artillery.

E. S. COLE, of the Pitometer Co., New York, was recently elected president and treasurer of that firm, succeeding John A. Cole, resigned.

Maj.-Gen. GEO. W. GOETHALS, of Panama Canal fame, has become the head of a new consulting engineering firm known as Goethals, Jamieson, Houston & Jay, Inc., with offices in New York City.

F. P. GUTELIUS, M.Can.Soc.C.E., general manager of the Canadian Government Railways, has been offered the position of vice-president of the Delaware and Hudson River Railway, and it is understood that he will accept.

RUDOLPH HERING, M.Can.Soc.C.E., announces that he is continuing in practice as a consulting engineer in New York City. The firm of Hering & Gregory has been dissolved, Mr. Gregory also continuing in practice individually.

Gunner THOMAS VINCENT McCARTHY, of Toronto, a graduate of the School of Practical Science, class '13, has been wounded in action. He was formerly employed as a civil engineer in the Works Department at Toronto.

Lieut. STEWART H. PEPLER, who was engaged as an engineer by the Toronto Harbor Commission before enlistment, has been wounded in action. He is a son of Dr. W. H. Pepler, of 600 Spadina Avenue, Toronto.

SYDNEY F. RICKETTS, A.M.I.E.E., has joined the staff of the Canadian General Electric Company, Toronto office. He was with the Ross Rifle Company until the government took over the factory, and has also been engaged in engineering work in England and China.

I. J. TAIT, formerly chief engineer at the Windsor Station, Montreal, has recently become associated with J. T. Farmer, Canadian sales representative for the Green Fuel Economizer Co., the Combustion Engineering Corporation of New York, Glenfield & Kennedy of Scotland, Drysdale & Co. of Scotland, and other well-known firms.

FRED W. WARD has been appointed chemist, A. CLIFFE assistant technologist, and G. H. CHAPMAN media maker, at the filtration plant laboratory at Toronto Island.

Lieut. A. M. WEST, city engineer of North Vancouver, B.C., has been wounded in action. Mr. West left North Vancouver in charge of a draft from the Sixth Engineers about August, 1915.

OBITUARY.

Major J. A. DeLANCEY, A.M.Can.Soc.C.E., reported missing and believed killed, was a member of the firm of Lighthall & DeLancey, Vancouver. He went to the front with a Nova Scotia regiment, was twice wounded, twice mentioned in despatches, and was recently awarded the Military Cross. Major DeLancey was at one time in charge of one of the plants of the Panama Canal.

Lieut. GORDON M. PEARCE, of Toronto, 21 years of age, who left the School of Applied Science to go overseas in August last with the "Pals" Battalion, is reported to have been killed in action on April 25th. He is a son of Mr. W. K. Pearce, manager of the Dominion Bank. His brother, Lieut. Rex Pearce, was among those who fell at the Somme in September last.

Lieut. CECIL V. PERRY, a graduate of the School of Practical Science, was killed in action on April 23rd. He had been two years in France and was recently decorated with the Military Cross. He was 22 years of age, and a son of R. S. Perry, 40 Howland Avenue, Toronto. He was a civil engineer in Northern Ontario at the time of enlistment. He joined the Eaton Machine Gun Section as a private and on arrival in England was granted a commission with the Royal Engineers.

S. R. SHELDON, vice-president and chief engineer of Sheldon's, Limited, Galt, Ont., manufacturers of heating and ventilating equipment, passed away recently after an operation for appendicitis. Mr. Sheldon was born in Bucharest, Rumania, in 1877, and moved to Galt when 7 years of age, and has lived there ever since. After receiving his education at Galt public and collegiate schools he attended Ridley College and the School of Practical Science. Mr. Sheldon was originally with the McEachren Ventilating Co. and about fifteen years ago took over the business with his brother, W. O. Sheldon. The company was at a later date incorporated as Sheldon's Limited.

Lieut. THOMAS NEWELL VICARS, of Renwick, Ont., a student of the School of Applied Science, 1911, is reported as having died of wounds.

Lieut. W. J. WITHROW, a graduate of the School of Practical Science, University of Toronto, and a son of the late Rev. Dr. Withrow, of Toronto, has been reported killed in action. On graduating he received an appointment in the Civil Engineering Department at Ottawa, but on the outbreak of war he enlisted with a machine gun detachment in Toronto. When he reached the front he was placed at the head of the topographical department at headquarters.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

NATIONAL PARKS ROAD CONSTRUCTION

FEATURES THAT DETERMINE ALIGNMENT AND GRADES—METHODS OF DRAINAGE, GRADING AND SURFACING—TYPES OF STRUCTURES USED—WORK OF A DOMINION GOVERNMENT DEPARTMENT IN THE GOOD ROADS MOVEMENT

By J. M. WARDLE, B.Sc., A.M.Can.Soc.C.E.,
Highway Engineer, Dominion Parks Branch, Ottawa.

THE Canadian National Parks are chiefly situated in the Rocky Mountain and Selkirk ranges,—the combined areas of the different parks including nearly 8,000 square miles of mountainous territory.

The park area in the Selkirk range is at present limited to some 563 square miles in the vicinity of Glacier and Revelstoke, B.C., the remainder of the mountain reserve being situated along the backbone of the Rocky Mountains range and lying between the forty-ninth and fifty-third parallels.

This large territory, in addition to its value as a mountain playground for the Canadian people and as a means of conserving the forest growth and wild life of Canada, is an invaluable commercial asset of the country due to the revenue derived from its tourist traffic.

Within the park areas are some of the grandest and most picturesque portions of the two great mountain ranges of the continent, and every park is rich in points of beauty and interest that annually attract thousands of visitors.

In 1915, Rocky Mountains Park, in which the town of Banff is situated, drew over fifty thousand visitors from all parts of the world, and at a conservative estimate these

Motor Road near Banff, Alta.

people alone contributed some $5,000,000 to the wealth of the country.

In 1913, before the outbreak of the war, the revenue derived from tourist traffic ranked fourth among the revenues produced by the natural resources of Canada. In that year it was estimated that the national income from tourist traffic was over $50,000,000.

When it is recorded that Switzerland with natural scenic attractions not superior to those of the Canadian Rockies, had an annual income of over $150,000,000 from tourist traffic, the great possibilities of this source of revenue are evident. The drawing power of the Canadian National Parks will increase as they become opened up and made more accessible to the travelling public, and

Moraine Lake Road and the Valley of the Ten Peaks (near Lake Louise, Alta.)

the essential factor of this development is the construction and maintenance of good roads.

This necessary development work is being undertaken by the Dominion Parks Branch of the Department of the Interior, by which the park areas are administered. Road location and construction in the different parks were originally left to a great extent to the judgment of local park superintendents. A few years ago, however, this important work was placed on a more definite engineering basis, and the location of park highways, and the greater part of their construction, are now under the immediate direction of the highways department of the Parks Branch.

Although the development of a system of park highways is still in its early stages, there are at present some 240 miles of graded roads in the National Parks, and new roads are being located every season. Roadwork generally has been greatly reduced owing to war conditions,—construction during the past two years being practically limited to the work performed by interned alien enemies who have been utilized to build several sections of park roads.

Location.—The location of park highways is generally proceeding on previously defined lines. Park highways may be divided into two classes:

(a) Main or trunk roads, and
(b) Secondary roads.

The first class comprise roads traversing the various parks that afford the chief means of communication with the outer districts, and roads that will eventually form part of the main chain of highways connecting the parks themselves. These highways, being most important, naturally receive first consideration from a location and construction standpoint.

Secondary roads are branches from the main roads to points of interest not touched by the latter. They in-

Switchbacks on the Yoho Valley Road in Yoho Park

clude loop roads and purely scenic routes. These secondary roads correspond in a physical sense to the feeders of a county road system, but their effect is more to distribute traffic than to concentrate it.

Of the total mileage of constructed roads in the Dominion Parks at the present time, approximately 90 miles can be classed as main or trunk roads.

The conditions to be considered in the location of park roads are different to those encountered in highway work in rural districts. Park highway routes are chosen with a view to develop scenic attractions instead of farming areas. The most direct and cheapest route between given points may not be the one that will afford the best road from a park viewpoint.

National park highways have little commercial traffic resulting from industrial production. Travellers of park

Section of Motor Road up Mt. Revelstoke in Revelstoke National Park. This road makes an ascent of 4,800 feet in 16 miles.

routes are generally on errands of recreation and enjoyment, and in a short time there will be employed but two means of locomotion,—the motor car on the highways and the saddle pony on the mountain trails. The requirements of motor traffic is therefore an all-important consideration in road location and construction work.

Actual location work in the field is controlled by three factors:—

(a) Grades and alignment.
(b) Construction cost.
(c) Scenic values.

Heavy grades and bad curves will lessen the popularity of a road good in other respects. The object of a proposed road location may not justify a high construction cost. The attractive value of a pretty waterfall may justify a greater expenditure than its value as a source of power. A well-located park road will therefore embody a careful adjustment of these three factors.

Alignment.—Owing to the rugged nature of the country included in the park areas a large portion of every road is necessarily located on mountain slopes, and the location line is generally high in curvature. Sharp curves with large intersection angles are sometimes unavoidable, and the alignment problem becomes one of determining the easiest curve with the least grading, or of adjusting the factors of safety and economy. A radius of 25 feet on centre line is the minimum employed on the location of park roads, and this small radius is never utilized unless circumstances demand the use of a switchboard on a steep sidehill slope. In all such cases provision

Section of Motor Road between Banff and Lake Louise, Constructed by Alien Labor.

is always made for the easement of the turn to a forty or fifty-foot radius by additional excavation when this work is justified by traffic. Apart from the case of the switchback no radius of less than 45 feet is employed on any park road, and sharp and abrupt curvature is avoided wherever possible.

Grades.—Considering the character of the country traversed by park roads, remarkably low gradients have been obtained. Main roads are located with a maximum of 6 per cent., and the majority of the grades are considerably less than this. Steady ascents or descents are made on grades between 4 and 6 per cent., and compensation for curvature is allowed on all sharp turns or switchbacks.

Roads of a secondary type usually traverse smaller, steeper valleys and more rugged country than main roads, and often present greater difficulty in location. Higher grades are therefore employed when necessary. Barring one or two cases where there is no alternative, these do not exceed 8 per cent. Generally the ruling grades on secondary roads are between 6 and 7 per cent.

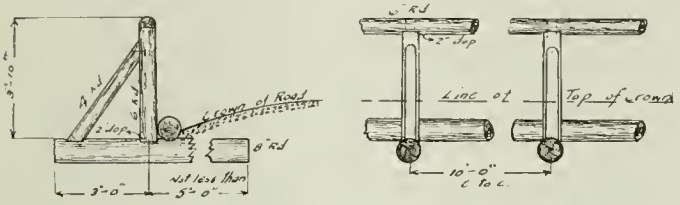
The usual procedure in the location of a new road is, first, a thorough reconnaissance of the country to be traversed for the purpose of determining the general

topography and what routes are available. Blazed lines are then run along the most promising routes,—the clinometer being used to keep within grade limits,—and the scenic possibilities and objective points are noted. A comparison of the probable costs of construction along the different lines is also made. If the information obtained is not sufficient to determine the best route, a rough line of levels is run or a rapid preliminary survey made, and sufficient data collected for the purpose.

On the line as finally located, curves are staked when the intersection angle exceeds seven degrees, and are run in by the tangent off-set method. When the numerical sum of the intersection angle and the proposed degree of curvature do not exceed 80 degrees, the length of the curve is computed by the standard railroad formula. When this sum is over 80, the formula of circular measure is employed.

Location field work is undertaken with a party of from 6 to 10 men, depending upon the character of the

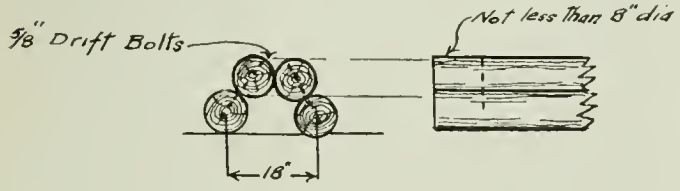
STANDARD GUARDRAIL AND WHEELGUARD



All Timber round and in the rough

country and the length of the proposed road. When the work is not conveniently near a railway line, supplies are transported by teams and wagons over existing tote roads, or pack-trains are used.

The total costs of road location surveys in the National Parks range from $55 to $75 per mile, depending chiefly



4 LOG DRAIN

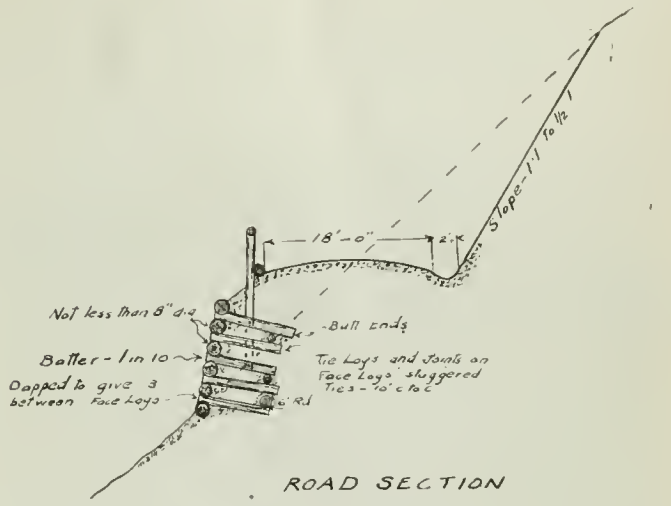
upon the nature of the country and the distance of the work from the source of supplies. These costs cover all lines, such as reconnaissance, preliminary or alternate lines, that may be run in connection with the location survey of the road.

Construction.—In view of the present requirements of the Canadian Parks, the work of construction is being confined to the building of good earth or gravel roads.

For uniformity of construction the roads in each park are built in accordance with standard plans and sections, modified if necessary to meet local conditions.

Clearing of the right-of-way is done to a width of 40 feet, and grubbing to 25 or 30 feet, depending upon the width required for grading. In order to prevent too rapid drying of the road surface where the ground is level and the soil very porous or sandy, clearing may be occasionally reduced to a width of 30 feet. Attractive clumps of fine trees are spared as much as possible during clearing operations.

The width to which a park road is constructed depends upon its importance and the amount of traffic it will have to carry, finished roadbeds varying in width from 15 to 18 feet. An additional width of from 4 to 10 feet is allowed at all sharp and dangerous turns. A superelevation of the outer edge of the road is also provided


18'-0"
Slope - 1:1 to 1½
Not less than 8" dia
Butt ends
Batter - 1 in 10
Tie Logs and Joints on Face Logs staggered
Dapped to give 3 between Face Logs

ROAD SECTION

ON STEEP SIDEHILL SHOWING CRIB AND GUARDRAIL

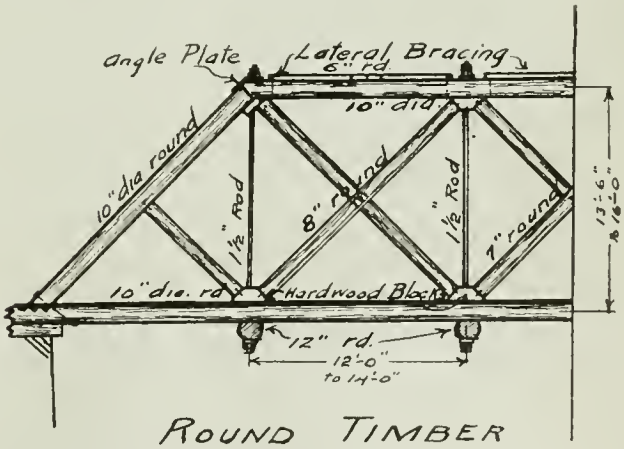
for at such points. The superelevation for any curve is obtained from the formula:

$$\frac{\text{width of roadbed} \times \text{degree of curvature}}{100}$$

the result being taken in inches.

Drainage.—In order to ensure rapid drainage of the road surface the degree of crowning adopted is one inch per foot,—the total crown for any road being one-half its width in inches.

Ordinary surface drainage is carried across the road when necessary by means of 4-log drains placed in the subgrade. In wet ground where there is no defined water course, these drains are placed from 150 to 250 feet apart and give very satisfactory results. While their capacity is sufficient for such conditions, they cost 80 per cent. less



ROUND TIMBER

TRUSS FOR 50 to 60 ft. SPANS

Half Elev.

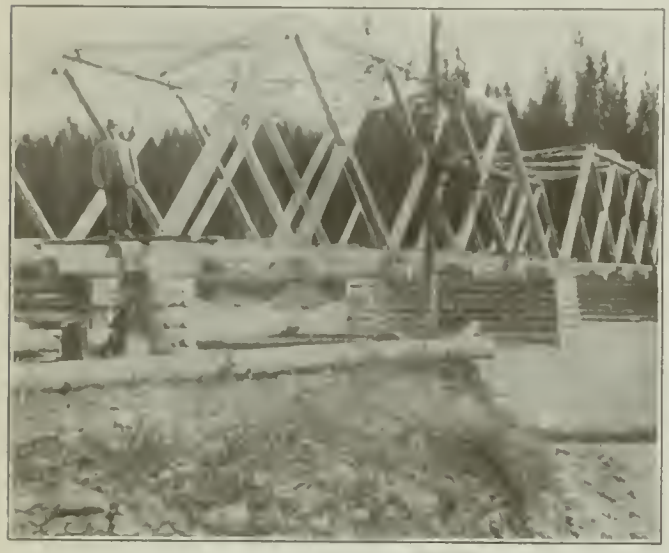
than the ordinary wooden box culverts and are very easily constructed.

For defined water courses and streams, box culverts of suitable sizes are provided, and are constructed to the full width of the roadway.

Owing to the singular conditions affecting the drainage of park roads, there is often considerable difficulty in

determining the proper capacity and best positions for drainage structures.

A large percentage of the park areas lies more than a mile above sea-level, and many of the roads are within one or two thousand feet of the timber-line. Combined with the steep mountain slopes, this results in the run-off from storms and melting snow reaching the roads very



Round Timber Truss Bridge Erected over the Kicking Horse River near Field, B.C.

quickly, and the maximum discharge of any channel may be reached in a few hours. These swift mountain streams have great powers of erosion and an entire change of channel may be effected in a few minutes' time.

Many streams carrying sediment, driftwood and boulders during freshet, deposit this material on reaching the gentler slopes of the valleys, and build up beds considerably higher than the general surface of the adjacent country. These conditions not only increase the difficulty of determining the proper locations and sizes of ordinary drainage structures, but in the case of the larger streams they introduce new problems in the selection of bridge sites.

Type of Drainage Structures.—At the present stage of development the general policy is to construct wooden cribs, culverts and bridges on all new roadwork. Since the park roads now in process of building traverse fairly well-wooded country, native timber suitable for construction purposes is available and is often obtained on the right-of-way.

The life of ordinary log drains or box culverts in the park areas is estimated at from nine to twelve years, and when they require re-placing, structures of a more permanent nature will be built. It is considered that by this time not only will increased traffic justify iron or concrete drainage structures, but that the roads themselves will require some type of surface paving.

Bridges are built of sufficient width to afford a minimum clear wheelway of 14 feet 6 inches,—15 feet being the usual wheelway adopted. The life of a wooden bridge is estimated at from 16 to 25 years, and it is considered that the width allowed will accommodate traffic during the life of the bridge.

For small spans of 25 feet and under, simple wooden bridges are erected, consisting of stringers and deck supported on wooden piers or bents. For spans between 25 and 40 feet a King type of truss is used, and for spans over 40 feet and up to 80 feet, the Howe or Warren truss is employed.

With the exception of the decking, which is sawn planking, bridges are usually constructed of native timber cut near the bridge site.

A unique feature of wooden truss bridges is the use of round peeled logs for truss members. Timber for trusses is carefully chosen and matched. It should not taper too quickly and should be as straight and as free from defects as possible. When neatly framed this type of bridge is pleasing to the eye, has a better appearance than a hewn structure, and is comparatively inexpensive to erect.

These bridge trusses are designed to carry loads of from 16 to 18 tons,—thus having sufficient strength to support a steam roller or a light revolving steam shovel. In computing the unit stresses for truss members of round logs, the cross-section available is taken to be the strongest rectangular section that could be obtained from the member in question.

Grading.—Grading of the roads is accomplished by ordinary methods, scrapers or wheelers and the scraping grader being used for general work. Where interned alien labor is employed, picks and shovels with dump wagons are utilized to a greater extent than on work done by contract or day labor.

The scraping grader has been found invaluable for ordinary grading on level ground, and has been successfully used on side slopes up to 1 in 5. In order to handle more quickly and profitably the large amount of excavation necessary where side slopes are very steep, a light revolving steam shovel, mounted on traction wheels, was purchased by the Parks Branch. On sidehill construction this machine does all the rough grading, and the trimming and finishing is done by a small force of men. It is also used for ordinary grading,—in conjunction with dump wagons,—when the amount of excavation per lineal foot is sufficient for profitable operation.

The amount of excavation per mile on park roads varies from 2,000 cubic yards on level ground, to 10,000 cubic yards on steep sidehill. The cost of grading under normal conditions ranges from 20 to 35 cents for earth,

Section of Motor Road between Banff and Lake Louise, Alta. This road when completed will be 38 miles long with a maximum grade of 6 per cent. Twenty-seven miles have already been constructed.

to $1.40 and $1.70 for solid rock. Intermediate material, usually classed as loose rock, costs from 50 to 70 cents per yard.

Surfacing Material.—One of the present problems in connection with the general roadwork of the National Parks is that of a satisfactory maintenance of the earth

and gravel roads, and the constant annual increase in motor traffic will make it increasingly difficult to maintain good road surfaces. It was early realized by the Parks Branch that surfacing of a more or less permanent nature would eventually be required, and a satisfactory material has been provided for by the reservation of tar-sand areas on the Athabasca and Christina Rivers in the vicinity of Fort McMurray.

The areas reserved by the Parks Branch for this purpose consist of two claims of one square mile each,—both claims being located with the view of not only including first-class material, but of affording easy mining and good transportation facilities. A projected line of the Alberta and Great Waterways Railway passes within two

Motor Road near Lake Louise, Alta. In background, Mount Temple, 11,626 ft.

or three miles of the reservations, and it is expected that the line will be constructed early enough for transportation requirements. The claims were located for the Parks Branch by an expert of the Department of Mines in 1914.

Analysis of the bituminous deposit shows the percentage of bitumen in the aggregate to be ample for road purposes, and extracted bitumen also compares favorably in tests with standard asphalts. A sample section of bituminous sand paving was laid in Edmonton, Alberta, and showed no effects of wear after a year's use.

From the data so far obtained it is estimated that there are 3,500,000 tons of high-grade material available in the two claims, or a sufficient quantity to construct 3,800 miles of sand-bituminous paving 2 inches thick and 15 feet wide.

Conclusion.—Highway work in the National Parks has not yet reached an advanced stage, and the great part of its development still lies in the future. In addition to the roads already constructed or projected, there are hundreds of miles of future highways whose routes at present are merely marked by the rough tote road or the blazed trail.

The construction of these highways will in due course be accomplished, and the best part of the National Park areas made reasonably accessible by a network of mountain highways.

The general outline of the present roadwork in the National Parks here given, indicates the steps being taken towards this ultimate aim of park highway development, and also illustrates the part taken by a branch of the Federal Government in the "good roads movement" of Canada.

WINNIPEG SUB-SURFACE FORMATION AND SUITABLE HEAVY FOUNDATION TYPES.

By J. Q. Rankin, C.E.

IN a consideration of the type of foundations suitable for heavy buildings and structures, it is necessary that there should be some knowledge of the character of the ground over which the structure is to be placed. This knowledge can only be had authoritatively from a study of the geological history and characteristics of the district in which the proposed building or structure is to be situated.

The purpose of this paper is, however, not to deal in detail with the geology of the Winnipeg District, but I believe that a generalized summary of the nature of the rock and overlying stratifications will doubtless make clearer the points which we wish to consider in connection with the types of foundations suitable for sustaining heavy buildings and structures.

Geological Formation.—The greater part of Manitoba overlies a part of an immense area of granite and associated rocks formed in pre-Cambrian time. After a period of erosion these limestones and associated rocks, such as the basal sandstones, were laid down during the Cambrian and Ordovician periods.

The present surface of the igneous granite lies at a depth of some 600 feet below the city of Winnipeg, but outcrops east of Winnipeg near the White Mouth River. The limestones were deposited in comparatively thin layers, from a few inches up to a number of feet in thickness, and are separated from each other by bedding planes (thin layers or films of clay). They are comparatively level, having an inclination of about 3 feet in a mile toward the west. They outcrop on the present surface about 20 odd miles east of Winnipeg and also about 12 miles west of the city. Directly under Winnipeg, however, the top layer of these limestones vary from 50 to 65 feet below the surface. They are largely of fossil origin. They are also water-bearing and the present artesian water supply of this district is drawn from them. Occasional breaks are encountered in the upper layers of this rock. They have the appearance of small gullies or ravines, as though having been formed by stream action, and are filled with a very fine white sand deposit.

After these limestone stratifications had been deposited there occurred a period of comparative rest—a lost interval—and no deposits of consequence occurred

until the Cretaceous period when heavy deposits of shale were laid down east of the mountains. These deposits terminated for the most part just west of this district, and we find no shale stratifications underlying Winnipeg.

Later we have the period of the great glacial drift, at which time a blanket of ice with its accumulated rock and sediment moved down from the north, over practically the whole of this immense basin. This blanket was thousands of feet thick, and its tremendous pressure, as it moved southward, doubtless created a grinding action on the surface of the limestone, so that in some localities this rock surface has been badly broken up and displaced. I have seen cases where the rock has been shattered much the same as though it had come from a rock crusher. In other places the surface was not disturbed in the same manner, but is seamy, as though having been cracked by the heavy pressure of the overlying mass. This difference in action to the surface of the rock may be accounted for by the glacier having deposited a protective layer over those sections where we find the limestone practically undisturbed. Consequently we find deposits overlying the limestone in one place of sand, gravel and boulders; in another a composite of shattered or broken-up limestone firmly cemented together with marle, and covered with a grayish-white clay and gravel; in another place we find this deposit in the form of hardpan. This so-called hardpan is usually composed of gravel, sand, small boulders and a tough, brownish clay, and is frequently called boulder clay. I have seen small quantities of the blue clay of this district close to the rock and intermingled with gravel and hardpan. This stratification resulted mostly from glacial drift passing southward over the surface of the limestone. It varies in thickness from 6 or 7 feet to 10 or 12 feet, and is water-bearing.

The glacial drift was followed by another period of rest, at which time much of this glacier melted, forming a lake which covered this district to a depth of some 500 feet. It was inevitable during this period that much of the sediment and rocks which had been carried down with the glacier would settle to the bed of this lake. Also that the stream action over the higher grounds to the west would move large quantities of clay and sediment down into this basin, from the shale beds to the west. And so we find in this district a layer of clay from 30 to 40 feet in depth, which we term blue clay. It is more or less homogeneous in texture, strongly alkaline and soapy in character, and practically impervious to the flow of water. It contains near its underside a sprinkling of boulders of various sizes.

Above this blue clay is a stratification of yellow clay, about 8 to 12 feet thick, and above this in turn a surface loam, a few inches to several feet in thickness. These last two stratifications have doubtless been deposited by streams. They are also water-bearing and carry surface drainage.

To summarize, we have the following stratifications overlying the rock. Beginning at the surface and working in the direction an excavation would be made they are as follows:—

First: A layer of loam being from a few inches to several feet in thickness.

Second: A layer of yellowish clay from 8 to 12 feet in thickness.

Third: A body of blue or slatish colored clay from 30 to 40 feet in depth, with a sprinkling of boulders toward the bottom.

Fourth: A conglomerate stratification of sand, clay and gravel; boulder clay or hardpan; grayish clay and gravel, overlying shattered limestone cemented together with marle. This stratification is from 6 to 12 feet in thickness. These different materials do not necessarily occur together, although at times several of the different substances are intermingled.

Bearing Capacities and Peculiarities of the Stratifications.—Before taking up the description of the different types of foundations we will consider the bearing capacities of the different stratifications, as well as some of the peculiarities which they exhibit when subjected to heavy pressure.

The surface stratifications of loam and yellowish clay are water-bearing and are ordinarily too shallow for the foundations of large buildings. Consequently, it is needless to discuss them. If used for foundations they should be most carefully drained.

Below these is the thick bed of blue or slatish colored clay which is practically impervious to water, and yet is semi-liquid in its action when subjected to pressure. This is the clay which has been used in the past for supporting most of the buildings in this district. It is a well-known fact that in almost every instance where a building of any material weight has been founded on this clay the building has shown signs of settlement. In some cases it is more marked than in others. In several instances the settlement has been so serious as to have forced the owners into underpinning the structure from bed-rock, by means of concrete piers. In the case of the better finished buildings and dwellings the settlement has been a source of annoyance and expense to the owners, in having to renew the decorations more frequently than would otherwise be necessary. In industrial buildings settlement is usually the source of the difficulty in keeping shafting in alignment and machinery level. This condition of the clay is due to the presence of a shaly material which has largely destroyed its frictional value. I have noted some marked instances of this sort when removing old piling from excavations. Invariably the piles had a film of clay adhering to them, and the pockets left after removing the piles were as smooth as glass. The outside of the clay film adhering to the piles being just as glossy.

I will note another instance of this condition which has come under my observation. At one stage in the righting of the C.P.R. North Transcona elevator a rather peculiar lateral movement of the entire building set up. This movement was caused by a slip in the clay bank on the low side of the building. The movement was only controlled and finally stopped after elaborate and extremely heavy shoring had been placed against the opposite side of the building. An examination at different points under the mattress disclosed a bed of blue clay an inch or two thick adhering to the under-face of the concrete, the lower surface of the clay, as well as the surface of the larger bed underneath it, had the same smooth and glossy appearance referred to in the case of the old piles which had been removed.

Still another instance of the apparent lack of frictional value is frequently evident when a vertical face of the clay is exposed without being retained by sheeting. I have seen chunks a cubic yard or more in volume drop out suddenly, without the least forewarning of their coming. Here again the exposed faces of the cavity, as well as the broken faces of the fallen chunk, have this same glossy appearance.

There are cases in this district where the railroads have made heavy fills for their tracks and the weight of

the fill has caused a settlement of the underlying ground and a consequent elevation of the prairie close by. This movement has been evident mostly in the surface stratas, but the blue clay has doubtless been affected also.

The bearing capacity of the blue clay is questionable. Few experimental tests have been made from which authoritative information has resulted. Most of the present knowledge has been gained from buildings which have been damaged by settlement. This knowledge is sufficient, or should be, to prevent further repetition of founding anything but the lighter structures on this hazardous material. And even then, architects and engineers should warn their clients in advance of the probability of some future settlement or movement, either from the structure's own contained weight or from its proximity to some piece of construction that may cause settlement.

As the city grows and expands larger and deeper excavations for buildings, sewers, waterways, subways, etc., are inevitable. It is impossible to prevent some loss of ground, and even though this loss may not be and probably is not noticed at the time, the surrounding clay is sure to find the void and fill it.

The hardpan, sand, gravel and gray clay, when free from water, has usually a greater bearing capacity than the blue clay. The hardpan, particularly when dry, is very firmly compressed and cemented, and at times is almost as difficult to excavate as rock. When it is wet it is more readily opened up. The gray clay, due to the presence of sand and gravel mixed with it, is also firmer when dry than the blue clay, but if submerged it becomes a semi-liquid.

There seems to be no regularity in the arrangement of this conglomerate stratification, and it is extremely unwise to assume that the arrangement and class of material found in one boring or test pit holds good for a large adjacent area. However, the arrangement of this stratification is not so important as the question of its being submerged. In the latter event its bearing capacity is certainly less. It and the underlying rock are both water-bearing, and under normal conditions they are submerged. Directly under Winnipeg the quantity of water is very much reduced and in some places entirely absent. This can doubtless be accounted for because the city and many privately owned wells are exhausting the water from this immediate section, for there is ordinarily an abundance of water in these stratas several miles from Winnipeg.

With the completion and use of the Greater Winnipeg Aqueduct, the city and owners of privately operated wells will doubtless cease pumping to a very large extent from their present source of supply. The inevitable result will be that the subterranean water will once more rise above the stratas overlying the rock.

This brings up an interesting question. Has this stratification already become sufficiently impervious from compression that a later saturation will not materially affect its bearing capacity? This question is worth careful consideration, and wherever accessible this material presents a fruitful opportunity for investigation. Also, to what extent will the alkalinity of this subterranean water cause a deterioration of concrete submerged in it? The engineer in charge of one piece of construction in Winnipeg has been so impressed by the possibilities of disintegration in concrete, that he has had it waterproofed to prevent contact with this water. To the writer's mind this is rather a costly procedure. In view of the fact that any disintegration would probably not penetrate more than an inch or so beyond the other surface, would it not be cheaper to make the piers a couple of inches larger to start with. However, the point is worthy of consideration and investigation.

We come now to a consideration of the limestone stratification. As has been pointed out in another part of this paper, the limestone was deposited in comparatively horizontal layers, varying in thickness from a few inches to several feet, and separated from one another by thin bedding planes of clay. In many cases the top layers of the stone are quite seamy and should be removed. No rock should be left that does not give forth a solid sound from a sharp blow of a sledge. With this test fulfilled the bottom is doubtless good for far more load than will be placed upon it.

Types of Foundations.—We may group the different types of foundations under the two main headings—the floating type, and the deep type—for every foundation in this district comes under one or the other of these classifications.

Floating Types: By floating type we mean those foundations which consist of spread footings, or a mattress (continuous or semi-continuous), resting on the blue clay or surface stratas, and depending on these stratas for their support.

The spread footings are, as the term implies, spread over a larger area than the wall or column presents and are intended to distribute the loading over a larger ground area.

These footings are usually made up of masonry or concrete and some of the oldest buildings have an additional timber pad next to the clay.

A mattress is merely an extensive spread footing and is continuous if it covers the entire area occupied by the supported building, and semi-continuous if it only supports adjacent walls or columns. The mattress is strengthened by reinforcing bars or grillage beams.

A mattress is far superior to spread footings in that it will prevent serious distortion and consequent cracking of the superstructure in event of unequal settlement in the building.

Deep Types: Those foundations which depend on receiving their support directly from the rock or the strata immediately overlying it by means of piles or piers are usually termed deep foundations.

Practically all the piling used in this district up to the present is of wood, but doubtless concrete piling will supplant the timber.

Timber piling, if completely submerged by water, will last indefinitely, but where the piling is partly or wholly out of the water, or is intermittently exposed to water and air, its life is considerably shortened. Of the available timber for piling, cedar seems to be the most durable under these conditions, with a life of perhaps 20 years, whereas tamarac is good for about 8 years and fir and spruce still less. The life of a timber pile embedded in the blue clay is problematical, and presents a subject well worth careful investigation. I have removed both cedar and oak piles from this clay and found them as sound as the day they were driven. On the other hand, I have removed tamarac and spruce piles which were in a very advanced stage of decay. It is, of course, possible that these piles were in poor condition before driving. It may, however, be just as true that the clay does not contain sufficient moisture to prevent some kinds of timber from rotting.

Concrete piling, either of the precast or poured-in-place types, has been used very little in this district. While they are more expensive in the first cost than the

timber piling, they will more than make up for this in permanence. Where piling is the suitable type of foundation to adopt and there is danger from decay so common in timber, concrete piles have already supplanted the wooden pile in many localities and will likely do the same in this district.

Wherever piling is used in or around Winnipeg it should be driven to refusal. It should never be stopped in the blue clay, depending entirely on its skin friction for its supporting power. While there is doubtless some frictional supporting power in this clay, it is safer to disregard it except as a means of lateral support, depending on the underlying stratas and the rock to carry the downward thrust.

The next type of foundations are those which are installed directly on the rock or in the rock by means of caissons or wells. This type presents the only dependable kind of foundation which can be installed, for two reasons:—

First: Because the foundation gets its support from rock, the only strata in this district which should be used for founding an important or heavy structure, and

Second: Because the method of construction affords a visible means of inspection of the class of material passed through, the bottom on which the foundation rests, and the placing of the concrete.

The pneumatic caisson is seldom used in this district, except for constructing deep bridge piers or foundations of heavy structures where it is not practical or economical to control the water volume with ordinary pumping units. Consequently this paper will not go into a detailed description of it.

The cast-iron-cylinder method of sinking wells is occasionally used in underpinning operations when working under conditions of an exceedingly heavy superimposed load, and where a very small loss of ground might prove disastrous to the building which is being underpinned or to adjoining property. The system of sinking wells by this method differs from the Chicago well method only in the manner of placing the well lining. After the excavation has been started a section of a cast-iron cylinder is set into the top of the excavation and jacked down. As the excavating proceeds, additional sections are placed, one at a time on top of the last one to be jacked down, and the jacking process repeated. The sections are provided with flanged ends (turned in) so that they can be bolted together. If necessary, the joints may be made water-tight with gaskets. By this process it is possible at all stages to keep the sides of the excavation protected against a cave-in.

Small diameter cylinders for shoring or underpinning purposes are sometimes installed by driving an open-ended pipe in the same way a pile is driven. The material is then excavated from the pipe by means of special tools and buckets made for the purpose, and the pipe filled with concrete. The two foregoing types are only used in exceptional cases where the construction conditions are peculiarly hazardous.

For ordinary conditions of underpinning existing structures or constructing foundations from the rock for new structures the Chicago well method is by far the cheapest and most satisfactory for this district. It has almost entirely supplanted rectangular wells from the standpoint of speed, economy and safety of construction.

This method obtained its name from the city where it originated and has been used very extensively.

The manner of constructing Chicago wells is briefly as follows: Excavate the well to the required diameter for a depth which will take the first set of lagging. Set the lagging and brace it firmly back against the clay with iron rings. Continue this sinking till there is depth for the second set of lagging. Place this in position so that the ends of the lagging pieces will butt up against the bottoms of the first set. Brace as before with iron rings. Continue this process until the well is finished.

The length of lagging used in each set is determined by the class and condition of material being passed through, the amount of pressure transmitted by it, and the length of time the excavation can be left unprotected against cave-ins or movement in the material. Care should be used in keeping the well plumb as the excavation proceeds. This can be done by placing the first set of lagging vertically and then plumbing each piece in the second set from the first set. Continue this rotation, plumbing each set from the one immediately above. A better method by far is to establish permanently your well centre overhead before starting the sinking. From this centre hang a plumb-bob which can be lengthened out as the sinking progresses. Always do the finished trimming by measurements taken from the central plumb string.

The trimming of the clay to receive the lagging should receive the greatest care, and none but experienced diggers should be permitted on this work, for considerable skill is required to do it properly. If the trimming is not carried far enough, difficulty will be found in placing the rings. If it is carried too far the joints between the ring flanges will have to be filled out with wedges to make the rings bear against the lagging. At the best, results from shovel trimming are uncertain, because of the voids left behind the lagging, and a loss of ground is probable from a movement in the clay to fill these voids. This difficulty may be overcome imperfectly by pouring grout behind each set of lagging as it is placed, but the remedy is slow and not entirely satisfactory. The writer devised and used on recent work a very simple little machine, operated by hand, that gives most positive results, leaving a face to the clay absolutely circular and without any unevenness.

In this connection the writer anticipates that a power-driven machine with a device for elevating the muck to the surface will before long take the place of the present method of digging by hand with shovels and elevating the muck to the surface in buckets operated by winches on the surface. About four-fifths of the sinking is through an even textured clay with no boulders or large gravel to interfere and this part of the excavation should be handled with a machine digger more economically and quickly than the present method.

The last eight to twelve feet of sinking through the conglomerate stratification overlying the rock is by no means so simple as sinking through the overlying clay. Under normal conditions this material is water-bearing, and extreme care must be used in lagging it to prevent cave-ins. Where water, however, has been drained out and the material has been permitted to consolidate and harden under pressure, much of the exposed face can be left safely without lagging. With the hardpan in this condition, sinking through it frequently is almost as expensive as going through rock. Picks make little or no impression on it. Bull points driven with sledges are effective but the progress is slow. We have had the best results from drills operated by compressed air. Wherever compressed air is available without a heavy installation charge, its use is advisable.

When water is encountered in sinking, pumps must be used. The available space for hanging pumps in a

well is limited, and only certain types of pumps are adaptable for this work. For all-round results we have found the Nye and Pulsometer types most effective, because they are small, compact, easily handled and are economical in operation. If one unit is not sufficient, additional units can readily be dropped down and operated in conjunction with the first.

CEMENT JOINTS FOR CAST IRON MAINS.*

By Clark H. Shaw, Assoc.M.Am.Soc.C.E.

THIS paper presents the method of making successful cement joints in cast-iron water mains. A brief history of the use of this joint establishes the fact that this method of construction has long since passed the stage of experiment, and has been proved to be an economic factor in laying such mains.

The process of making the joints is described and illustrated, some experiments in jointing are described, cases showing the strength of cement joints under trying conditions are cited, and data relating to cost, etc., are presented.

About 1886 a cast-iron pipe line for water distribution was laid with cement joints at Redlands, Cal., and in 1891 joints of that kind were used at Los Angeles, Cal., but evidently with questionable results, as the method was not adopted. In January, 1907, Mr. Charles Thornburg,

Fig. 1.

Fig. 2.

then superintendent of one of the water companies operating in Long Beach, Cal., decided to try cement joints for a 16-in. cast-iron pumping main, and instructed his foreman of construction, Mr. F. M. Shrode, to conduct some experiments.

No definite process was outlined to the foreman, but his experiments and practice in repairing steel riveted water mains under pressure, by using a dry mixture of neat cement in caulking the bands around these pipes, gave him an idea that a moist cement could be caulked into the bell solidly, and would produce the results desired. It was probably Mr. Shrode, who, by this experiment, finally perfected the joint and used it in construction of the entire line. When this line was completed and put into service, working under a static head of about 190 ft., several places showed some seepage, particularly at the lower end of the line, where the work was started, and it was decided to re-caulk these joints at the first opportunity; it was noticed, however, that the moisture was gradually drying up, and the seepage finally ceased.

Cast-iron construction was then abandoned by this company until 1911. During that year the works came into the possession of the municipality, and the writer was appointed engineer of the water department. After looking into the merits of the cement joint, as used on this 16-in. pumping main, it was adopted as the proper method of construction, and since that time it has been used throughout the entire system.

Long Beach now has 60 miles of cast-iron water mains, ranging from 4 to 24 ins. in diameter, laid with

Fig. 3.

joints of this type. All these pipes are under pressures ranging from 40 to 80 lbs. per square inch, and are giving perfect satisfaction.

Method of Making the Joint.—In making the cement joint the pipe is placed and spaced in the usual manner. A thin backing of the best dry jute is used instead of oakum, as the jute is free from oils and grease (which should be avoided). A Portland cement, conforming to the specifications advocated by the American Society for Testing Materials, is used. The dry cement is placed on a piece of canvas (usually a cement sack ripped open), and moistened just so that when thoroughly mixed by hand it will be of such a consistency that when gripped tight it will hold the form of the hand (Fig. 1), and when dropped 12 ins. it will crumble (Fig. 2). The canvas containing the cement is placed under the bell, and the cement is tamped into place by hand with a caulking iron until the bell is about half full (Fig. 6). It is then caulked with heavy blows until the cement is thoroughly packed in the back of the socket. This process is continued until the bell is packed solid out to the face (Fig. 7). A small bead of neat cement in a plastic condition is then put on, using the caulking iron as a trowel (Fig. 8). As soon as the initial set of the cement in the bead has taken place, the joint is covered with earth to protect it from the air and sun. In back-filling, the excavated material is always settled with water, which helps to cure the exposed portion of the joint.

The bead is essential, in the writer's opinion, as the cement packed in the bell is so dry that without protection

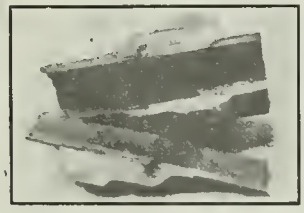


Fig. 4.

Fig. 5.

it would absorb moisture from the water used in settling the trench, and it is believed that, should the joint develop seepage when the pressure is put on in the main, the cement, being dry, would expand and aid materially in keeping the joint tight.

Experiments on cement joints constructed without the bead showed that, 24 hours after completion, they absorbed water readily. In cases where seepage has developed and has subsequently closed, it is assumed that the dry cement absorbed the moisture from the inside, expanded, and filled the seepage pores.

About 20% of the cement is wasted by falling off the canvas or being thrown out by the caulker. If any dust

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or earth from the trench falls on the canvas or in the cement, it is immediately taken out, together with enough cement to make sure that the remainder is clean. In mixing the cement with water, care is taken that there shall be no lumps in the material, no matter how small. If any cement is left on the canvas when a joint is completed, it is used on the next joint, provided the work is continuous, otherwise new batches are made. Special blunt caulking tools are used (Fig. 3).

The joint is allowed to stand 48 hours before the pressure is turned on and the main is put into regular service. Cement joints have been used with satisfactory results, however, 12 hours after completion, but this is not considered safe practice. Pressure tests are never made by the writer prior to putting a main into service.

At San Diego, Cal., a pressure test was made by caulking a 6-in. cast-iron tee, one side of the tee being filled with a plug and each of the two ends filled with short lengths of cast-iron pipe with plugs caulked in the ends. As the pieces of pipe caulked in the tee were scrap ends cut from other pipes, they had no bead on the joint end, and, notwithstanding the fact that the joint was made with smooth pipe, it took a pressure of more than 300 lbs. per square inch to force the pipe out. The test was made about 48 hours after the joint was made.

In another test, made at Winnipeg, Man., three lengths of 6-in. pipe were laid with four cement joints, on January 13th, 1916. After 6 days, pressure was put on the pipe, in increments of 25 lbs., and the joints were found to show no leakage or moisture, up to 125 lbs. At 150 lbs. one joint showed moisture on the surface of the cement.

On January 24th another test was made, and at one joint moisture appeared at 175 lbs. On January 31st this joint showed moisture with 200 lbs., and also on March 15th, with a pressure of 255 lbs. This joint was the weakest of the four. The pressure was kept on the pipe about one-half hour in each case.

Fig. 5 is a section of a joint made with a cut piece of pipe, and shows the position of the jute and the cement when there is no caulking rim or bead on the end of the pipe (as in the San Diego test). The cement bead, as shown in Fig. 4, was made larger than usual, and covers the entire face of the bell, though normally it covers only about one-half.

The strength and rigidity of the cement joint are shown by the following instances where cast-iron mains have been subjected to severe tests: A new trenching machine was being tested by a sewer contractor in Long Beach, Cal. It is operated parallel with and 5 ft. from a 6-in. cast-iron water main, with cement joints, which had been laid in January, 1915. The trench dug by this machine was 3 ft. wide and 18 ft. deep. Some time before noon on February 1st, 1915, the side of the trench next to the water main caved in, leaving about 40 ft. of the pipe hanging and supporting about 2½ ft. of earth on top of it. This condition was not reported until the next morning, and at nine o'clock braces were put in to support the pipe. The main was under a pressure of about 65 lbs. per square inch at the time. There was not the slightest seepage from any of the joints as result of this strain.

Again, in June, 1915, 94 ft. of 4-in. cast-iron pipe with cement joints fell into a sewer trench, as the result of a cave-in under conditions similar to those just described. This pipe was under a pressure of about 55 lbs. per square inch. At one end it broke at a service connection; at the other end it broke near the spigot end of a pipe, about 8 ins. from the joint, letting the whole 94-ft. section fall into the trench. In this case every cement joint remained intact. This line had been laid in March, 1913.

Several thousand feet of 8 and 10-in. cast-iron water mains with cement joints have been laid in made ground, the fill being silt from the dredging of harbor channels;

(Concluded on page 447.)

Fig. 6.

Fig. 7.

Fig. 8.

WATER SUPPLY STANDARDS.*

By William J. Orchard,
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WATER supply standards may be divided into two classes, *viz.*, technical standards and non-technical standards. Technical standards may again be divided into two classes, *viz.*, official standards (formed by the promulgation of laws and regulations), and unofficial standards (which may be defined as those based on experience or current practice).

A résumé of legislation and the regulations of supervising health bodies indicates that the only definite technical standard that has officially been promulgated in the United States is that of the secretary of treasury, under date of October 21, 1914, being "A bacteriological standard of purity for drinking water supplied to the public by common carriers in interstate commerce."

From information available, it would appear that none of the state health departments have officially promulgated standards of purity, either bacteriologically or chemically. In many states, legislation exists prohibiting pollution of public water supplies, or the sources from which they are obtained. A few of the state health departments recognize the standards of the Treasury Department and aim to have all water supplies conform to these limits. Other state departments of health have official standards which are used as a means of guidance in interpretation of water analyses, most of these being bacteriological standards only.

Reports received from thirty-one state health departments indicate that thirteen states have laws protecting water supplies, but have not adopted any minimum chemical or bacteriological standards. Two states have laws protecting water supplies and have unofficially adopted United States Treasury standards. Nine states have laws protecting water supplies and have adopted tentative unofficial standards, while eight states have neither laws nor standards.

Unofficial or tentative standards that have been adopted by some of the state departments of health are of interest. A few examples are enumerated:—

Minnesota.—The Minnesota State Board of Health has not set any arbitrary standard for the purity of water. In interpretation of results, a water is not considered to be of good sanitary quality unless the bacteriological count for four days at 20° C. is less than 100 per c.c., and B. coli absent in 100 c.c. samples. This standard is subject to qualification under certain conditions. The Minnesota State Board of Health will not report on any water supply unless a thorough field investigation has been undertaken and unless samples have been collected by their own representatives. This phase of the situation is presented in a paper by H. A. Whittaker, director of the Division of Sanitation of the Minnesota State Board of Health, entitled "Fallacies in the Investigation of Water Supplies," which was presented before the engineering section of the American Public Health Association in October last.

Alabama.—The Alabama State Board of Health recognizes the standards adopted by the Treasury Department, allowing, however, a bacteriological count of 300 per c.c. after twenty-four hours' incubation at 37° C.

Virginia.—The State Board of Health of Virginia has not adopted any standards and in an interpretation of analyses is largely governed by the particular conditions surrounding the source of supply, and even though a water derived from a protected watershed on which there is no habitation, might show coli in 1 c.c. and 10 c.c. samples, unless human contamination could be shown, the water supply might be considered as good. For the information of local authorities, however, the Virginia State Board of Health indicates on its standard report forms, the significance of bacteriological counts and B. coli interpretations, differentiating between bad, suspicious, or good supplies, as follows:—

"Where colon bacilli are found in quantities of 1 c.c. of water, the sample is dangerous, and is reported bad, regardless of the number of other bacteria found in the sample.

"Where colon bacilli are found in 10 c.c. or 20 c.c. of water, and the number of other bacteria is large, the sample is regarded as dangerous, and is reported bad.

"Where colon bacilli are found in 10 c.c. or 20 c.c. of water, and the number of other bacteria is small (less than 500 per c.c.) the specimen is classed as suspicious.

"Where colon bacilli are not found in samples, and where bacteria are less than 500 per c.c., the sample is reported good."

Maryland.—The State Department of Health of Maryland has not established any standards or limits on the quality of public water supplies, but certain standards have been recommended for filtration plants. These standards are quite novel and are based on the coefficient of efficiency which is defined as "the ratio of the logarithm of raw water count at 20° C. to the logarithm of the plant effluent count." For the removal of colon, the standards are based on a so-called "standard hygienic efficiency" which is defined as "The sum of the percentages obtained by allowing a value of 20 per cent. to each successive step in the colon removal." These standards are discussed in detail in a paper by Wolman, published in the American Journal of Public Health, November, 1916.

Montana.—The Montana Department of Health has adopted tentative chemical standards for the hygienic purity of waters, applicable to restricted areas in the state, and as a rule, only supplies that show no B. coli in 10 c.c. are recommended for public consumption.

California.—The California Bureau of Sanitary Engineering considers a supply in which B. coli cannot be confirmed in 10 c.c., by the latest laboratory methods, as being safe. The occasional occurrence of B. coli in the same quantity is not considered seriously, but their presence in 10 c.c. continuously, or in less than that amount occasionally, is not considered favorably. Condemnation is usually reserved for a field inspection to determine if possible what portion of the B. coli are of human origin.

Iowa.—Iowa presents the interesting situation where chemical standards adopted for the waters of the state several years ago, have been abandoned, following the collection of information showing their inadequacy.

A résumé of reports received from over thirty state health departments shows the varied interpretations placed on bacteriological analyses, and the relative importance given to sanitary survey of watersheds in conjunction with analyses.

If the standards of the U.S. Treasury Department must apply to all water supplies used in interstate traffic, and if, as experience has clearly shown, supplies used by railroads can conform to Treasury standards, the interesting contention is presented that all public water supplies should conform at least to this standard.

*Paper read before the Chemical and Bacteriological Section of the American Water Works Association, May 10th, 1917.

If all supplies do not measure up to this standard, the regulation works an injustice on a few supplies, and does not accomplish a general improvement in the water supplies of the country, as might otherwise be the case.

If there are two towns, located one on either side of the state boundary, designated as A and B, A being a watering place for railroad equipment, and B being a way-station, according to existing legislation, the supply of A must conform to the Treasury standard, and the supply of B can be anything that the state and local officials will permit. To make the water supply of A conform to the standards, has, in all probability, placed a burden either on the water company or the taxpayers of the municipality, and has correspondingly improved the welfare of the town. Is it equitable to require A to go to this expense and not to impose a similar obligation on B? On the other hand, in justice to the consumers at B, should they not be afforded the same protection as those at A?

It is appreciated that in suggesting the feasibility of adopting tentative minimum bacteriological standards, that the principal objection to such procedure is the inability properly to consider the sanitary surroundings of the source of the water.

The abundant good that has been accomplished on a relatively few supplies, following the establishment of Treasury standards, however, would indicate that a considerably greater number of supplies could be improved, should minimum standards be promulgated for all of them.

Whether or not we are governed by arbitrary or tentative standards, more or less definitely fixed, those who in the course of their work are called upon to interpret large numbers of bacteriological analyses, unquestionably are governed by standards that they have set, upon which the interpretation is based, and this interpretation is made, first, without reference to a sanitary survey; and, secondly, in conjunction with a sanitary survey to determine, if possible, the sources of any apparent pollution. But these personally established water standards vary with the individual's interpretation of the analyses.

A water showing coli in 1/10 c.c. regularly will unquestionably be condemned, as would also, without doubt, a supply usually showing coli in 1 c.c.

A water showing coli frequently in 5 c.c., and occasionally in 1 c.c., would very likely be rejected by most sanitarians, although the frequency with which such supplies are furnished to consumers, without rigorous steps being taken to improve the quality, is surprising.

When we reach a water, however, with coli present frequently in 10 c.c. quantities, and occasionally in smaller amounts, the interpretation of the analysis lies very largely with the individual, and may be rejected or passed, in accordance with the individual's standards.

Although the difficulties of arbitrarily establishing any minimum bacteriological standard are appreciated fully, it would tend greatly to improve the quality of a great number of supplies, if minimum standards adopted after careful investigation, were to be officially promulgated by this association.

Should such standards be available for water companies, commissioners, and consumers, a definite object would be established, and the best results in any line of endeavor are secured only when a definite objective is in view.

On the other hand, should such minimum standards be established, being intelligently drawn, and formed only after due consideration of geographical conditions, they would unquestionably aid the supervising health officials in dealing with the recalcitrant water vendor, for the state sanitary engineer would have a definite objective that he could order the vendor to reach.

Although the United States Treasury standards are high, as compared to many water supplies in this country, and although a large number of waters of our bigger and better-known cities would not at all times conform to the Treasury standard, it is not high as compared to the standards existing in European countries and Great Britain.

It was expected that a considerable fund of authenticated information would be available to incorporate in this article to cover standards prevailing in these countries, and the limits of bacteriological content that are considered good practice. Presumably, this information has been lost in transit and will have to be incorporated subsequently. Many English waterworks men, however, contend that the total bacteriological content after 24 hours' incubation at 37° C. should not be more than 50 per c.c., and that colon should be absent in 100 c.c. quantities after 72 hours' incubation at 37° C., and some even go as far as to aim to have colon absent in 200 c.c. after 72 hours' incubation at 37° C.

An examination of the "Twelfth Research Report of the Metropolitan Water Board," of London, would indicate that the settled, stored and treated waters of various supplies before filtration, were comparable bacteriologically with some of our American water supplies as delivered to the consumer.

In advocating the adoption of minimum bacteriological standards of water, the object in view would be to improve the poorer supplies, and to establish a guide by which non-technical waterworks men could appraise their supplies. To establish standards not so much as an arbitrary means of appraisal as an incentive to secure better water supplies.

It is therefore suggested that consideration be given to the appointment of a sub-committee to determine the practicability of adopting standards similar to the U.S. Treasury standards for all waterworks, whether they be used for interstate traffic, or not.

Non-technical Standards.—Technical standards are easily explained in scientific terms intelligent to those familiar with their use. Non-technical standards are more difficult to explain, but may be defined as the attitude of the non-technical man toward a water used for domestic purposes. These may well be divided into two classes:—

(1) The standards of the non-technical waterworks man.

(2) The standards of the consumer.

It must be realized that there are a very vast number of waterworks men in this country, not members of this association, who do not know to any extent the necessity of a pure water supply, and to whom the colon bacillus and bacterial flora in general are unknown. Fortunately, the number of waterworks in charge of this type of man is fast diminishing.

The only reason that so many non-technical waterworks men are entirely unfamiliar with the need of safe water, and the care and vigilance that must be used to secure a safe supply, is that they do not know the fundamental reasons for a safe supply.

Two instances are worthy of mention:—

A certain surface water supply in New England upon investigation, following a typhoid epidemic, was almost definitely found to have been polluted by a typhoid carrier hunter. The State Board of Health representative, sent to install a temporary treatment plant, was ordered out

of the pumping station by the water commissioners, who waited on him in a body, to inform the Board of Health man that they were running that waterworks; that the water supply suited them; and, State Board of Health or no State Board of Health, he could not install the treatment plant, and the only thing he could do was to get out, which, having no authority under the law, he did.

The second instance is that of a waterworks superintendent of a small municipality which was required by the State Health Department to install a treatment plant. Upon the arrival of the representative of the company furnishing the purification apparatus, the superintendent roundly abused the State Board of Health officials, ridiculed the necessity of treatment, in spite of the prevailing epidemic, and informed the representative that he was not going to permit the State Board of Health to install any more contraptions that would mean more work for him; and that although he would treat the water while the State Board of Health man was around, he would pay absolutely no attention to the equipment at other times. Subsequent experience has indicated only too well that he carried out this threat.

Such attitudes on the part of non-technical waterworks men are only too familiar to those whose work has as its foundation the improvement of water supplies in general, and it can be combatted only by a most aggressive educational campaign which properly should be supervised by this association.

Contrast with this attitude that of the progressive private water company or the water department conducted by a technical man, or by individuals who realize the vital importance of their work. The large, progressive water companies or departments take every possible means at all times to improve their water supplies; to raise the standards by which they are appraised; and, by which the consumers are influenced. Such water companies, by taking the consumers frankly into their confidence, place themselves on such a firm foundation as to be able to withstand whatever adverse criticism may be directed against them.

The experience of the Indianapolis Water Company, of Indianapolis, Ind., which has taken its patrons into its confidence in regard to the treatment of its water supply and has established a reputation in Indiana of furnishing absolutely safe water under all conditions, is worthy of note. This confidence has carried the water company without criticism through two severe epidemics and has been invaluable in the matter of dollars and cents as well as good-will. A similar attitude on the part of other companies has had a comparable result.

Is it not incumbent upon this organization to endeavor to create a similar attitude on the part of every water vendor?

The water standard set by the consumer is for the most part one of appearance. If a water is not turbid or colored, he is usually satisfied. Unless his immediate family has been vitally touched by the effects of an impure water supply, he is not solicitous about the quality of the supply. This matter was discussed at length in Mr. Johnson's paper, "The Typhoid Toll," presented before the last annual convention of this association and was amplified in the printed discussion of that paper.

The consumer is, however, inextricably connected with the establishment of higher standards for a water supply. To obtain better water supplies, money is needed and a considerable quantity of it. A water company cannot improve its supply without incurring expense, which should bring return in the shape of increased rates, and increased rates can only be obtained with the partial consent at least of the consumer. Similarly, municipal supplies, if improved, increase the tax rate, and here again the consumer is the court of last resort.

The complacent and erroneous impressions that many water consumers have in reference to their supplies must be eliminated by careful, painstaking publicity and education. In discussing water supplies of various communities with non-technical men and water consumers, one is frequently advised that the water supply is the purest in the country; that it is 99 9/10 per cent. pure; or, that it is well water that never sees the light of day and is absolutely safe. The individual cannot be blamed for resting secure in these assertions, for he does not know better.

Most of those present at this meeting, in going into a strange city or town do not drink the water furnished until the nature of the supply has been ascertained. Many of us abstain from drinking water when on road trips, even in territories where other liquid refreshments are not easily obtained, simply because we appreciate the pollution that a water may carry and the danger that may lurk in a tumblerful. The average consumer, however, seldom gives this matter a thought, because his training has not taught him to do so.

Should this association be instrumental in making the water consumer stop before he draws a tumblerful of water and inquire as to the purity of that supply before he drinks the water, it would have a tremendous effect on the improvement of water supplies.

A more complete and masterful presentation of the value of pure water than that contained in Mr. Johnson's paper, "The Typhoid Toll," was probably never presented before any association. In it, Mr. Johnson, in his admirable manner, tells us that more people are killed every year by typhoid fever than by railroads. The water consumer will stop and look before he crosses a railroad track; we must make him stop and think before he drinks a glass of water. Mr. Johnson has shown us that a pure water supply is a good dollars and cents business proposition—why not treat it as such? Why not pattern our conduct as a waterworks association after that of a successful business organization? Are we not all of us, waterworks superintendents, engineers, chemists, bacteriologists, manufacturers, or what not, offering our services and our product—water—to our final customer—the consumer? Being honorable men, we want to give him the best that he will pay for, and he will only pay for the best when he is educated to its need. With the consumer educated, and demanding the best in water supplies, there will be no further danger from the non-technical, disinterested, or slovenly waterworks vendor, for he will not be permitted to do business.

Looking at this matter, then, as a business proposition, seeking to find a market for a water supply of higher standards than most of those at present furnished, should it not be approached in the same manner as any successful business campaign? Given a good product for which there is a market, the success of any business depends on bringing that product to the attention of those using it, and that can only be done by advertising and publicity.

Why not have this association act as an advertising or publicity medium to obtain higher standards on the part of the technical and non-technical waterworks man and also the consumer? Begin with the consumer—advertise to him the value of better water so that he will demand the best, and be willing to pay for it. Then he will get it.

The efforts toward improvement made by vendors of water used in interstate commerce, which could not be certified under Treasury ruling, are significant of what can be done under compulsion. How much more could be accomplished if the consumer was the compelling force all over the country?

We are all familiar with the progress made in campaigns to secure better housing, better factory conditions, better environment for employees, and protection from occupational diseases. We are also familiar with the tremendous strides in the anti-tuberculosis campaign, and the many exhibits used to educate the public along these lines. Many state health departments have travelling exhibits in charge of medical or technical men, which tour their states to give the public visible evidences of the results obtained from money they have expended.

Are we not lacking in the fulfilment of the highest objective of this association unless we endeavor by every means at our disposal to educate the general public as to the value of pure water? Are we not stultifying the influence of Mr. Johnson's paper if we confine it, for the most part, to the technical waterworks man? Should we not see to it that its contents are advertised broadcast as a good business proposition?

Let us suppose that graphic illustrations of the value of pure water were to be incorporated in every public health exhibit in the country; were to be made part of travelling exhibitions; to be incorporated by the boards of education in instructions given in school rooms, and disseminated by every educational medium—it would not be long before the demand for better water would be so insistent as to cover the entire country.

And, with the objective of creating this demand, on the part of the consumer, and thus offsetting the deleterious influence of the careless water vendor, and to support the technical waterworks man in the promulgation of higher standards of water supplies, this suggestion is offered: That this association appoint a committee to consider the feasibility of a joint board to consist of four members, one each appointed by the presidents of the American Water Works Association, the New England Water Works Association, the American Public Health Association and the Water Works Manufacturers' Association; these four men to appoint a publicity or press agent, who might well be one of the secretaries or editors of those associations, whose sole duty would be to spread the propaganda of better water supplies. There are many problems presented,—the cost of broadcast publicity at first would be prohibitive, but intensive advertising campaigns could easily be conducted in certain localities.

Sub-committees could be appointed to confer with various state departments of health, covering publicity in their territory. Other sub-committees could be appointed in some states, if necessary, to endeavor to secure legislative enactment to protect water supplies, and create an interest in the subject. Arrangements could be made with some of the larger private water companies to advertise steps they have taken to protect their supplies along the lines previously mentioned as having been undertaken by the Indianapolis Water Company. Other sub-committees could make arrangements with the boards of education, libraries and exhibits.

This is a tremendous undertaking, but unquestionably it is worth while. It is a campaign which would take years to properly cover the country, and it is not to be expected that the tangible results would be immediate. That the end to be accomplished is a good one is beyond dispute, and in aiding to spread the gospel of Pure Water this association will fulfil its highest function.

DEFICIENT RAILROAD FACILITIES.

Some striking statistics are contained in the majority report of the Railroad Inquiry Commission, signed by Sir Henry Drayton and Mr. A. M. Acworth, as to the lack of rolling stock and other facilities so far as Canadian railways, with the exception of the Canadian Pacific, are concerned. The effect of deficient railway facilities upon the country's business, it is pointed out, is very serious. It is best shown in a period of stress, whether the stress is due to traffic congestion or is the result of bad weather conditions.

"February last gives a good example," says the report. "The traffic was very heavy; embargoes were the rule and not the exception; weather conditions were worse than usual even in winter. The Grand Trunk had handled over the lines in its Ontario district in February, 1916, 318,532 cars. Last February it handled only 195,120. In its Eastern district in February, 1916, the company handled 210,914 cars; and in February of this year only 109,567 cars. This failure has occurred at a period when the demands on the country for food supplies, munitions of war and other articles used by the Allied armies, are extremely heavy. The situation is one which calls loudly and insistently for an immediate remedy.

"In fairness to the Grand Trunk, it should be pointed out that congestion inevitably causes a falling off in the volume of traffic handled. Cars which are insistently required for the necessities of life, such as coal, perishable foods, live stock—and under present circumstances munitions—have at all hazards to be got forward. This necessitates greatly increased yard-work and switching. Preferential treatment of any one class of traffic always retards the general movement, and so adds further to congestion.

"The Canadian Pacific is a well-organized line. Its movement also fell off in Eastern Canada. Its two districts probably most nearly comparable to the Grand Trunk's Eastern and Ontario Lines are its Ontario and Quebec Districts. In February, 1916, the Canadian Pacific handled in its Ontario district, 92,255 cars, and in 1917 only 80,414 cars. In its Quebec district it handled, in February, 1916, 130,045 cars, and in February, 1917, only 96,464 cars. The resultant percentage decreases are for the Grand Trunk in its Ontario division 39.37 per cent., and for the Canadian Pacific Railway in its Ontario district 15.58 per cent. For the Grand Trunk in its Eastern Division, and for the Canadian Pacific in its Quebec district, the percentage decreases are 48.5 per cent. and 25.82 per cent. respectively.

"At a later page of this report we refer in another connection to the fact that the Intercolonial has no terminals of its own at Montreal, but uses those of the Grand Trunk. The congestion of February was more a terminal congestion than a rail congestion, and the Intercolonial business out of Montreal was directly affected by the congestion of the Grand Trunk terminals. The Intercolonial movement in the First Division out of Montreal in February, 1916, amounted to 25,446 cars, and for the same month in 1917, to 15,628 cars, a percentage decrease of 38.58 per cent. The Intercolonial system, however, as a whole, had a movement, in February, 1917, of 51,311 cars, as compared with 66,510 cars in February, 1916, a percentage decrease of only 22.83 per cent., while the Grand Trunk for its entire system handled, in February, 1916, 652,358 cars, and in the same period in 1917, 402,133 cars, a percentage decrease of 38.35 per cent."

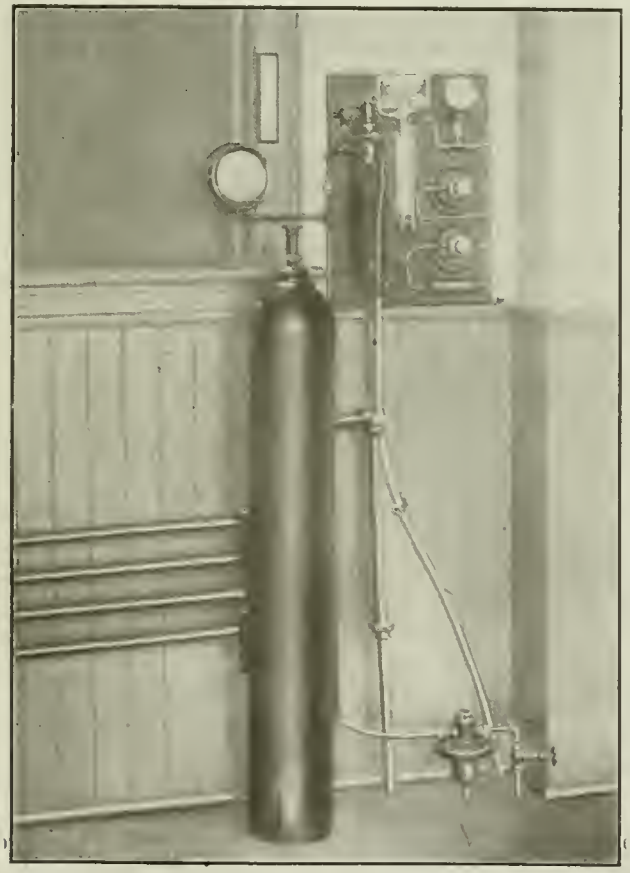
COLLINGWOOD PUMPING STATION.*

By E. J. Stapleton,
Superintendent, Collingwood Water and Light Commission.

THE waterworks of the town of Collingwood was first installed in 1889-1890. A pumping station was built on the Georgian Bay, 250 feet from the shore and a mile from the centre of the town. As formation of the earth was limestone, a trench was excavated and the water was piped in by gravity to a well 6 feet by 24 feet, which was excavated under the pump house floor, the bottom of the well being 14 feet below the lake level.

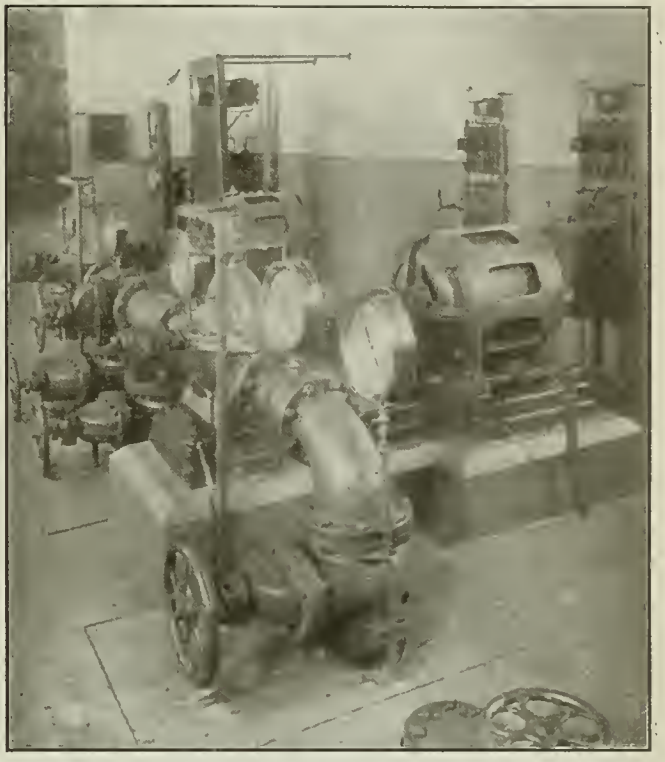
Two steam pumps "compound" of 1,500,000 gallons capacity each were purchased from the Kerr Engine Works, of Walkerville, and connected with the well by means of suction pipes. These pumps have been in commission from that time until last summer, when electrically driven turbine pumps were installed.

Collingwood has a population of 7,010. The average daily water consumption for 1916 was 770,000 gallons. When pumping by steam the coal was brought in by water and the average yearly cost of the fuel was $4,300,000. Each year's operation showed deficits that could not be avoided while water was being pumped with steam and worn out pumps.



Chlorinating Plant at Collingwood. Capacity, 10 ounces an hour.

The writer submitted a report to the Water and Light Commission early in 1915, showing that these deficits could be wiped out by the use of electric pumps. The matter of layouts and types of apparatus was later discussed with the engineers of the Hydro-Electric Power Commission and afterwards I again reported, recommending that 2 single stage De Laval pumps, each of 1,000 Imperial gallons capacity be installed, the pumps to be direct connected to induction motors of 75 h.p., 2,200 volts. The piping was arranged so that the pumps could be operated either separately or in parallel for domestic purposes, and in series for fire use.



Electrically-driven Pumps at Collingwood. Also showing Switchboard and Venturi Meter in Background.

It was also found necessary to build a new well to receive the gravitated water from the lake. The rock was excavated to a depth of 16 feet below the lake level and a well was built, the inside diameter of which was 12 feet by 25 feet deep. The well was built of Portland cement, 5 to 1. The walls of the well are 15 inches thick, reinforced. The top of the well is 8 inches thick, reinforced with a manhole opening 4 feet square. An iron ladder was also built into the walls of the well.

The frazil ice in the lake sometimes chokes the strainer at the mouth of the intake pipe, and whenever this happens the water immediately commences to fall in the well, so that for the guidance of the engineer on duty, a float was installed in the well, to which was attached a flexible wire rope, conducted over pulleys to a counterweight suspended in the pump room.

A Jefferson bell-ringing transformer was purchased and connected with the lighting system of 110 volts to an 8-inch gong. It is so arranged that, as the water falls in the well the counterweight in the pump room rises and automatically closes the switch, which rings the gong. This alarm gives the engineer plenty of time to open up an emergency shore valve on the suction pipe before there is any possibility of the pump impellers being left in operation without water.

The well complete cost $2,000. The turbine pumps and motors cost $7,138. This tender covered the cost of

*From Hydro-Electric Power Commission of Ontario Bulletin.

the pumps installed, which included in addition to the pumps, 2 Crocker-Wheeler 75 h.p., 2,200-volt induction motors, with a 25 per cent. continuous overload guarantee, also the compensators, oil switch, integrating wattmeter, the necessary piping connections and valves, including two 12-inch suction pipes and a 14-inch Venturi meter. The local commission purchased and connected up some 250 feet of 14-inch cast iron pipe, connecting the discharge from the turbine pumps with the discharge from the steam pumps and force main. It also erected a brick building with a pitch and gravel roof and did all the necessary rock excavating for the pipe trenches, building the necessary foundations.

After the installation was completed an official test was conducted on the pumps and motors. The electrical end of the test was conducted by Messrs. Fisher and Dandene, of the Hydro-Electric Power Commission, and the pump tests were in charge of Messrs. Chipman and Austin, of the Turbine Equipment Company and also the writer. The efficiency and power factor of the motors slightly exceeded the guarantee given by the Crocker-Wheeler Company. The pump readings were checked up with the readings on the Venturi meter recorder. The recorder indicates the ratio of flow from hour to hour. The results of the tests made on the pumps also slightly exceeded the guarantee given by the Turbine Equipment Company.

The total cost of the installation, including foundations, excavations and a brick building, was $13,777.91. Debentures were issued for $13,000 twenty-year term. The debentures realized $13,480.69 and 5½ per cent. interest. The yearly fixed charges on these debentures is $1,087.83. The approximate cost of electric power per year is $1,500. Coal for heating the building and carrying 40 pounds steam on one boiler as requested by the underwriters, approximated $450. In other words, the $1,500 here mentioned is only transferred from the water department to the electric department and goes back to the users of Hydro in the way of a reduction in Hydro rates; thereby effecting a cash saving in electric power over steam of $3,850 per year, and an actual net saving to the waterworks system of $2,350 per year.

The motor-driven pumps are not operated during the local peak hours, unless, as frequently happens, such additional load can be carried without affecting the maximum monthly peak on the town system. When such conditions exist, however, the pumps are operated 24 hours daily for the remainder of the month.

The intake pipe extends out into the lake 1,000 feet in a depth of 15 feet.

A chlorination plant has just been installed at the request of the local health board. The plant is the liquid process, model F, gravity type, regulating apparatus with a capacity of 10 ounces per hour, having a sight reading meter graduating from ¼ ounce to 5 ounces per hour under 25 pounds back pressure. The chlorine is purchased in 100-pound cylinders from the Electro Bleaching Gas Company, of Niagara Falls, N.Y. The object of the health board in authorizing that the water be sterilized was to guard against any possible infection which might be caused by pollution from boats and also the spring and fall freshets.

The Canadian Government Railways recently placed an order for fifty locomotives with the American Locomotive Company.

The Council of the Canadian Society of Civil Engineers has approved of the change in name of the "Regina Branch" to that of "Saskatchewan Branch."

THE ELECTRIC FURNACE.*

By Leo G. Denis, B.Sc.,
Hydro-Electric Engineer, Commission of Conservation.

The use of the electric iron and steel furnace has made exceptional progress under war conditions. When the demand for steel exceeds the supply, and junk piles are searched for available metal, the electric steel furnace experiences a boom because it is capable of making an excellent quality of steel from a comparatively poor quality of iron and steel scrap. As more and more careful conservation of natural resources becomes necessary, electrical processes steadily gain ground because of their greater economy in the use of raw materials.

At the beginning of 1910 there were 73 electric steel furnaces in the United States producing 100,000 tons per year; to-day there are over double this number with a yearly production exceeding 1,000,000 tons. These furnaces require in the neighborhood of 150,000 h.p., one of the largest single installations having a total capacity of 70 tons in units of 15 and 20 tons.

The relative growth in Canada is even greater; the electric furnace steel production has increased from 61 tons in 1915 to 43,790 tons in 1916. In Montreal alone, according to figures supplied by the Civic Investment and Industrial Co., there are in operation, or being installed, 11 electric furnaces requiring a total of 17,000 h.p. The larger furnaces, when fed from high-tension lines and properly controlled, offer no serious disturbances to their circuits, but a plant of less than 5,000 h.p. capacity should not attempt to carry single-phase furnaces of 400 k.w. or over. The possibilities as an off-peak load are good as the usual length of heat is only about three hours, which condition would adapt itself excellently to a limited service operation. The furnaces can be operated economically at from 1c. to 1½c. per k.w.h. and such rates are now in force in many Canadian centres for ordinary services such as house lighting.

*From "Conservation."

G.T.R. WILL OPPOSE NATIONALIZATION.

The Grand Trunk Railway is opposed to the nationalization scheme outlined in the Drayton-Acworth report. A. W. Smithers, chairman of the board of directors, arrived in Montreal last week. Newspaper reports state that the London board of the G.T.R. resent the references made in the report to the finances of the Grand Trunk. It is said that they will fight the nationalization of the G.T.R. and claim to have the financial resources to make any required improvements or additions to equipment. It is understood that a Canadian board in charge of policy and management will be forthcoming if the road remains an independent company.

It has been reported in Washington, D.C., that negotiations looking to the purchase of more than $100,000,000 worth of railway locomotives, cars, rails and other equipment in the United States will be one of the main purposes of the Italian war commission, which is expected to reach that country in about three weeks. A large part of the $100,000,000 already loaned by the United States to the Italian government also is likely to be spent for railroad materials, and orders probably will be placed during the Italian commission's stay here. Italian railways, which are government-owned and operated, are reported to be suffering greatly from lack of equipment since most industrial plants formerly supplying the roads now are making munitions.

NEW BUSINESS TAX ACT.

THE business profits war tax act, which came into force in 1916, will operate until 1918. Under its provisions, incorporated companies were taxed 25 per cent. on net profits exceeding 7 per cent. upon capital employed (throughout the accounting period) of $50,000, or over. The profits of a business owned other than by an incorporated company, were taxed 25 per cent. on net profits exceeding 10 per cent.

The taxation applies also to businesses with capital less than $50,000 and making munitions to the extent of 20 per cent. of their output.

The amendment to the act, introduced by Sir Thomas White in the House on May 1st, 1917, changes the fixed tax to a progressive one. A company's profits up to 7 per cent. are exempt. On profits from 8 per cent. to 15 per cent. inclusive, 7 per cent. is exempt, the balance being taxed 25 per cent. On profits exceeding 15 per cent. to 20 per cent. inclusive, 7 per cent. is exempt, 8 per cent. will be taxed 25 per cent. and the balance (not exceeding 5 per cent.) will be taxed 50 per cent. On profits exceeding 20 per cent., 7 per cent. is exempt, 8 per cent. will be taxed 25 per cent., 5 per cent. will be taxed 50 per cent., and the remainder will be taxed 75 per cent. How this progressive tax works on the profits of a company with capital of $100,000, for example, is shown in the accompanying table.

Capital employed includes (*a*) amount of capital stock of a company paid up in cash (or a fair valuation of such stock if issued against any other consideration than cash); (*b*) actual unimpaired reserves, or accumulated profits. An incorporated company's capital (plus unimpaired reserve, rest or previously accumulated profits if used as capital) existing at the beginning of the accounting period is the basis for the allowance of the 7 per cent. exemption.

The amended act provides that the increases in the tax "shall be levied against and paid by the person owning such business for each and every accounting period ending after December 31st, 1916." The tax, therefore, will cover most of the year 1916 for a large number of companies, but those whose fiscal years conform to the calendar year, will not pay the additional taxation during the latter part of 1916. The tax apparently is computed for the full year for each company from the beginning of the accounting period. Where the company's year ends January 31st, 1917, the tax commences from February 1st, 1916.

In the original act, the tax was retroactive and to be levied for three years upon the net profits shown to any accounting period (fiscal year) after December 31st, 1914. Dividends received from the stock of any incorporated company taxed under the act, were not included in the profits taxed. Reasonable deductions from gross profits for depreciation, renewals, etc., were allowed.

The periods during which the tax was payable under the old act were as follow: Any company, firm or individual which was liable on July 1st, 1916, to a tax on two or more accounting periods covering two years, the tax covering the first twelve months could be paid on November 1st, 1916, the tax covering the second twelve months on November 1st, 1917; and the third and last year's tax on November 1st, 1918. Interest at 7 per cent. is chargeable on taxes in arrears.

The amended act applies to all incorporated companies or private firms to which the original act applied.

HOW THE NEW BUSINESS WAR TAX WORKS ON PROFITS OF A COMPANY WITH CAPITAL OF $100,000

	A company, with capital of $100,000, earning		Will be free of taxation up to 7%	The company will pay on the balance of its profits:								Thus, of total profits of	The company will retain of profits		Government will retain as tax of profits		
				25% of		50% of		75% of									
	%		$	$	or	$	or	$	or	$	or	$	%	or	%	or	$
1	10		7,000	3,000	750	—	—	—	—	—	—	10,000	9¼	9,250	¾		750
2	15		7,000	8,000	2,000	—	—	—	—	—	—	15,000	13	13,000	2		2,000
3	20		7,000	8,000	2,000	5,000	2,500	—	—	—	—	20,000	15½	15,500	4½		4,500
4	25		7,000	8,000	2,000	5,000	2,500	5,000	3,750	—	—	25,000	16¾	16,750	8¼		8,250
5	30		7,000	8,000	2,000	5,000	2,500	10,000	7,500	—	—	30,000	18	18,000	12		12,000
6	50		7,000	8,000	2,000	5,000	2,500	30,000	22,500	—	—	50,000	23	23,000	27		27,000
7	100		7,000	8,000	2,000	5,000	2,500	80,000	60,000	—	—	100,000	35½	35,500	64½		64,500
8	200		7,000	8,000	2,000	5,000	2,500	180,000	135,000	—	—	200,000	60½	60,500	139½		139,500

REPORT SAYS GOVERNMENT SHOULD CONTROL NEW RAILROAD EXPENDITURES.

THE majority report of the Railway Inquiry Commission expresses the opinion that instructions should be given by the government forthwith, without waiting for further action on this report, to the Canadian Northern and Grand Trunk Pacific companies to discontinue all expenditure on works in hand, unless and until express permission is received for their continuance.

This part of the report continues as follows: "It is to be anticipated that difficulties, more or less great, will need to be overcome before a final settlement can be reached with the Grand Trunk and Canadian Northern Railway Companies. We realize that, if the matter were dealt with in the ordinary manner, it might be a matter of months, if not years, before a final settlement was reached. The pressing public interest demands that the matter be not so treated.

"We will enumerate certain other matters that will not brook delay. In the West the Canadian Northern is not giving, and is not able to give, adequate service to the grain-growers in some important districts which are dependent on its lines. The situation in the Goose Lake district is highly unsatisfactory. The branch is in bad shape and is not fit to do the business offering. There is absolutely no room for doubt as to the lack of freight cars and the resulting inconveniences, and even in many cases distress. In the East the position of the Grand Trunk is most unsatisfactory. Beyond question the system immediately requires at least 200 more locomotives and at least 10,000 freight cars. If coal famines are to be avoided, and the proper winter movement kept up, the line from Burlington Junction to Fort Erie urgently requires double tracking. The question of electrification ought to be taken into consideration forthwith.

"If things go on as at present, the traffic conditions of this year will in all probability return in an aggravated form next winter. The old equipment will be a little older, the roadbed will be in a little worse condition. And the situation in Eastern Canada has been so bad this winter, that there has been much difficulty, specially at Grand Trunk points, in maintaining a supply of grain and flour from the West. It is imperative that strong and efficient action be immediately taken.

"Recognizing the probability of delays, caused by the efforts of the companies to secure better terms from the government, we think that, in order to protect the business interests of the country, the government should immediately put itself in a position to obtain orders appointing receivers for the Grand Trunk and Grand Trunk Pacific systems. We recommend that, at the present sitting of the House, an act be passed constituting the Board of Trustees, so that, in case receiverships are necessary, the trustees may, on the application of the government, under its existing rights as a creditor, be appointed receivers. They would then be in a position to take, through the courts, the necessary steps to vest the properties in the Dominion Railway Company so as to constitute the new system that we have recommended. Should the companies show themselves ready and anxious to come to a prompt agreement, actual application to the courts would of course not be made.

"We feel that the appointment of receivers is not in the interest of the country's credit. It certainly is not in the interest of the companies, as the evidence of this report shows that the property of the Grand Trunk Company, if it were put into a receiver's hands, would leave little or nothing for the shareholders. The result of court proceedings would probably be to divest the shareholders of all interest, and to place the government in the position to take, to the fullest extent, the advantages of their legal position as holders of defaulting securities. But, though we hope receiverships will not be necessary, we think the government must face the possibility.

"In the case of the Canadian Northern Railway Company no proceedings in court are requisite. Under the provisions of section 24 of the Canadian Northern Railway Guarantee Act, 1914 (4-5 Geo. V., chap. 20), the Governor-General-in-Council has power, when authorized by Parliament, to declare by Order, if default is made by the company in payment of interest on the $45,000,000 guaranteed securities (the interest on which is at present being found by the government) that the equity of redemption of the company is absolutely barred and foreclosed; and thereupon the whole property becomes vested in His Majesty.

"If receiverships become necessary, the advantage of appointing the trustees as receivers is obvious. The trustees, with the government behind them, and with the approval of the court, would be in a position to operate the roads as a combined system, to purchase much needed rolling stock, and to make essential improvements, in a way that no ordinary court receiver could do. Receiverships in the ordinary sense would only result in greater traffic congestion than ever, and in losses . . . at large."

SEWAGE TREATMENT ESSENTIAL.*

By Leo G. Denis, B.Sc.,
Hydro-Electric Engineer, Commission of Conservation.

Progress in water purification constitutes one of the brightest pages in the history of sanitary engineering in America during the past 25 years, but much remains to be done both as regards its general adoption and its application where local conditions call for special treatment. Apparently, progress in water filtration has been somewhat retarded through efforts to make chlorination serve as a substitute under conditions where it is not entirely adequate. Chlorination has done much to improve public water supplies. But it is not a cure-all, and its limitations are far more clearly appreciated with the practical proofs now existing than when academically recited six or eight years ago.

Under certain conditions chlorination secures public water supplies of good quality without filtration. The great difficulty lies in gauging the proper amount to be introduced. For many water supplies subject to chlorination without filtration, real difficulties are encountered in so adjusting the dose of chlorine as to guard against objectionable taste and odors on the one hand, and inadequate destruction of objectionable bacteria on the other.

Present-day consideration of sewage disposal as related to water supplies assumes that the primary source of supply is not grossly polluted and that any sewage affecting its purity has been treated in order that its filtration for domestic use may not be rendered ineffective through the overloading of the filters. The methods adopted must involve the recognized principle that any water filtration process must begin by the treatment of the sewage before it is allowed to contaminate the source of water supply.

*From "Conservation."

CEMENT JOINTS FOR CAST IRON MAINS.

(Continued from page 438.)

also several thousand feet of 8-in. cast-iron pipe have been laid in fine beach sand; all are giving perfect satisfaction. An 8-in. cast-iron main with cement joints was laid in filled ground (the soil being clay) with only 6 ins. of covering above the pipe when the line was put in service; the fill was then completed to 18 ins. above the top of the pipe, and was rolled with a 14-ton steam road roller, without causing the slightest seepage in any of the joints. The rolling was done preparatory to paving the street in which the pipe was laid. This was a very severe test of the merits of the cement joint. At the time this rolling was done, had any seepage developed, it would have been readily detected, as the whole line was within 3 ft. of the edge of the fill. The fill was completed to a width of 80 ft., 3 months later, leaving the pipe 12 ft. from the centre of the street.

In several instances a cast-iron main laid with cement joints has settled 3 ins., or probably more, in loose or filled ground, without developing any leakage. In fact, there is only one case that the writer can recall where the cement joint was not satisfactory. This was in a 6-in. cast-iron main on a dock, about 3 ft. from a railroad track. Many joints in this pipe have developed seepage, and some have small pin leaks, but the leakage is not considered serious enough to warrant closing down the line for re-construction. This failure may be due to faulty construction, as the pipe was laid when the making of cement joints was in its infancy. However, the main is situated so that it cannot be entirely covered.

Removing Cement-Jointed Pipes.—Fig. 5 shows a completed joint. The cement joint can be taken apart in a very simple and economical way. The pipe is uncovered about one-half, or a little below the centre. At the joint where the original bell-hole was dug, the trench is usually made wider on the sides (but not deeper under the pipe), in order to permit the caulker to work at the joint. The upper half of the joint is cleaned out with a cape-chisel; then, with tripod and blocks, the free end of the pipe is raised until the lower half of the joint breaks free from the bell. The pipe seldom has to be pulled out of the bell, as it nearly always works itself out as the free end is lowered. If portions of the cement stick to the spigot end of the pipe, or fail to be entirely crushed in the bell, it is a very simple matter to clean out the bell with a cape-chisel, or knock the cement from the spigot with a hammer.

On occasions, after a joint has been cemented tight in the line, it is necessary to cut it out entirely (such as for laying a valve on its side; turning a tee or Y in another direction; adjusting a tee to conform to or meet a grade; avoiding a sewer connection or any other unforeseen obstacle). Table 1 has been compiled from records of the actual time spent in doing such work.

Table 1.—Time Required for One Man to Dig Out a Complete Cement Joint, Without Removing the Fitting or Gates from the Line.

Size.	Time.
4 inches	18 minutes
6 "	22 "
8 "	26 "
10 "	30 "
12 "	38 "
14 "	48 "
16 "	60 "

Table 2.—Data Relative to Cement Joints.

Size of pipe, in inches.	Rings of jute per joint.	Jute per joint, in pounds (approximate).	No. of joints per 94-lb. sack of cement.*	No. of joints per 8-hour day (one caulker).
4	2	0.14	24	50
6	2	0.19	18	42
8	2	0.24	14	34
10	3	0.43	11	28
12	3	0.51	8	24
14	3	0.58	7	20
16	3	0.66	6	17
18	3	0.73	5	14
20	3	0.80	4	11
24	3	0.95	3	7

*Including the 20 per cent. of cement wasted or left over.

The writer has never cut out a joint on a main of greater diameter than 16 ins. It is fair to assume that to cut out the upper half of a joint, for the purpose of removing a pipe, would take only one-half the time indicated in Table 1.

At Long Beach unit costs have been kept on all construction, covering nearly the entire 60 miles of cast-iron water mains. Table 2 has been carefully compiled from these unit costs, and presents data concerning cement joints.

GOOD RESULTS OF ONTARIO GOVERNMENT RY.

The total mileage of the Temiskaming and Northern Ontario Railway in operation at the end of 1916 was 454 miles, according to the fifteenth annual report of the road. The total operating revenue was $2,138,121, as compared with $1,550,403 in the previous year, and the operating expenses were $1,594,177 in 1916, as against $1,356,049 in 1915. The net operating revenue, therefore, was $543,944 in 1916, as against $194,353 in 1915. Total earnings were: $528,705 in 1916, $210,538 in 1915. The payroll totalled $1,127,885, as compared with $953,209 in 1915, and $216,119 in 1905, the year in which the road commenced operation.

Other figures are: Revenue per mile of road, 1916, $6,508; 1915, $4,719. Expenditure, per mile, 1916, $4,852; 1915, $4,128—a betterment in net revenue in 1916 of $1,064 per mile operated over that of 1915. During 1916 the commission spent $463,604 on equipment and improvements, as against $112,000 in 1915.

SASKATCHEWAN BRANCH, CAN. SOC. C.E.

At a meeting of the Saskatchewan Branch of the Canadian Society of Civil Engineers held at the Assiniboia Club, Regina, on May 10th, the following officers were elected for the year: Chairman, L. A. Thornton, Regina; vice-chairman, G. D. Mackie, Moose Jaw; secretary, J. N. de Stein, Regina; executive, H. S. Carpenter, E. G. W. Montgomery, Regina; A. H. Dion, Moose Jaw; C. J. Yorath and Prof. A. R. Greig, Saskatoon.

It was decided to hold a public meeting at Regina on May 25th, when railway problems will be discussed, and a similar gathering will be held in Moose Jaw some time in August.

The Dominion Government has spent $17,790,587.74 on the construction of the Hudson Bay Railway and the Port Nelson terminals.

W. J. FRANCIS ADDRESSES SASKATCHEWAN BRANCH OF CAN. SOC. C.E.

Regina, Sask., May 19th.—Walter J. Francis, of Montreal, who is a councillor of the Canadian Society of Civil Engineers, addressed the members of the Saskatchewan Branch of the Society last week at the Assiniboia Club. Mr. Francis told about the newer spirit now dominating the engineers of Canada, who feel that they should take a more vital interest in public life of the Dominion.

He called attention to the fact that there is not an engineer member of the Senate or House of Commons at Ottawa, and yet engineers are extremely important members of the community, whose work is necessary to the building up of the land.

The speaker then dwelt on the activities of the Society, and said that it is now preparing a memorial which was to be presented to Sir Robert Borden upon his return from Europe, calling attention to the fact that large engineering and other public works are being executed in Canada by alien engineers and contractors, and also giving instances of large public undertakings by Canadian engineers. Alien engineers, according to Mr. Francis, are being employed on the St. Lawrence River work and by the Dominion Railway Board of Engineers, and even one of the largest corporations in Saskatchewan is at present employing an alien engineer in the supervision of its largest structure.

The speaker also mentioned the Lindsay Arsenal contract, which was let by the Dominion Government to an American firm.

"We shall mention in the memorial that in future the government will be held strictly responsible for any similar cases. We shall seek full recognition for Canadian engineers from the federal and provincial governments," declared Mr. Francis.

Attention was also called by the speaker to the memorandum which was recently presented to the government in reference to the proposed plans for the industrial development of Canada. A suggested plan had been drawn up by four members of the Society and Sir Chas. Ross. One of the practical results of this was the appointment of the honorary advisory council on industrial and scientific research, which had received a government grant of $200,000.

AM. SOC. C.E. CANCELS ANNUAL CONVENTION.

The American Society of Civil Engineers has issued a circular to its members cancelling the annual convention which was to be held June 12th to 15th, 1917, at St. Paul and Minneapolis, Minn. The circular states that on May 7th the War Department authorized the formation of nine volunteer engineer regiments for immediate service in France, and this action caused the executive of the society to realize that many members would not be able to attend the convention, so it was unanimously decided that the wise course to pursue was to abandon the 1917 convention. The next annual convention of the society will be held at St. Paul and Minneapolis provided that it is the desire of the membership in that locality, and thereafter the rotation of place for holding the convention in the various districts of the society will be maintained as previously. It is said that quite a number of other United States engineering organizations which hold annual conventions have taken similar action.

TO DISCUSS REPORT ON MONTREAL AQUEDUCT

A meeting of the ratepaying engineers of Montreal who have been opposing the Montreal Aqueduct scheme, as at present constituted, has been called to discuss the report made to the city by Messrs. Vautelet, St. Laurent and McRae. Controller Villeneuve is also preparing a report on the same subject. A newspaper interview quotes the controller as saying that so far as he can see the report concurs with the opinion of the ratepaying engineers that the present aqueduct scheme is impracticable. He remarked, however, that only three questions had been definitely answered by the Vautelet-St. Laurent-McRae commission out of the seven which had been submitted to them, the others being "indirectly hidden" in the body of the report.

WALL ST. COMMENT ON RAILROAD REPORT.

The Wall Street Journal says editorially:—"Further consideration of the majority report of the Royal Commission appointed to inquire into the railways and transportation of Canada does not make it convincing. It is clear enough that the commissioners acted in good faith and were free from that taint of politics which is often the bane of public affairs in Canada. President Smith of the New York Central makes a suggestion that may well come from one of the most brilliant operating railroad men in the country, who knows how the Canadian railroads should be run to work out their own salvation, and does not particularly know or care where the money to do it comes from. The lack of indicated capital supply is the weakest feature of his minority report.

"But the majority report, while sincerely disclaiming any attempt at government ownership, goes much further than government ownership. The idea is to take 25,000 miles of railroad out of politics and to do so by creating a self-perpetuating committee to handle the most staggering railroad proposition even this continent has ever seen.

"Canada went crazy over railroad development and is now reaping the consequences. The attempt to save something out of the mess is praiseworthy, but the suggestion of Sir Henry Drayton and Mr. Acworth that a non-political commission could manage the proposition is visionary. Either the commission suggested would become more autocratic than government ownership itself in its worst form, or it would become the tool of the political party in power, because the patronage of 25,000 miles of railroad could not fail to tempt the politician, and there is nothing in the history of Canada to show that the politician would fail to succumb to the temptation.

"Mr. Smith's plan involves financing to an extent which he probably does not entirely appreciate, but at least it is sound railroad ownership on a common-sense basis, where the stockholder could take his risks and lose his money or make his profits as fate might determine. The Drayton-Acworth plan disclaims government ownership, which it can well afford to do. It proposes to send good money after bad, and to deprive holders of stock with no earning capacity of the only thing that remains to them—their equity in the railroad future."

EIGHTY MILLIONS FOR AIR DEFENCES.

"Before summer, Canada will have a $5,000,000 aviation camp located at Camp Borden," says "Flying," in its April issue. "It will be the largest permanent establishment of its kind on this continent. Fifteen concrete sheds 120 by 66 ft., lighted and heated by electricity, are now being finished, and when the barracks are done, the camp will accommodate about 2,000 men. This camp represents the first step taken by the Canadian Government in establishing its permanent air defences, for which $80,000,000 are to be spent. Hitherto the greater number of aviators have been trained at Valcartier, but this camp will soon be given up for this kind of work, on account of the short season there, with its great amount of snow.

"There will be 160 experienced military aviators constantly on duty at Camp Borden, either trained by the experts of the Curtiss Company, or selected from 600 Canadian airmen now in service on the battle fronts of Europe. These 600 men form an available reserve of pilots, who have heard the shrapnel swish by them in actual battle, and know every detail of organization, as well as the work to be done in the air. Plans include training 5,000 aviators, but it is not expected that the training of more than 2,000 will be finished this year. As soon as pilots are graduated from the school they will be assigned to permanent camps, which will be scattered all over Canada."

HERRON BROS. GET JUDGMENT.

Justice Masten last week at Toronto gave judgment in favor of the plaintiffs in the suit of Herron Bros. vs. Canadian Stewart Co. to recover 90 per cent. of the price of piles said to be delivered to the defendants. The latter argued that a large portion of the piles had been rejected by the engineers of the Harbor Board.

Editorial

MR. CHAMBERLIN'S STATEMENT.

Mr. E. J. Chamberlin, president of the G.T.R., has issued a statement to the public taking exception to a number of figures quoted in the majority report of the Railway Commission. At the time the report was issued Mr. Chamberlin wrote to his shareholders saying, "At a later date a full statement with regard to the company's position will be made," so it is to be presumed that the statement now given out, which occupies about three and a half newspaper columns, is the full statement to which Mr. Chamberlin previously referred and represents the full comment that the railway has to make upon the commission's report.

If this is so, it is particularly noticeable that no reference whatever is made to Grand Trunk Pacific finances and but very little to the capital expenditures said to be required by the Grand Trunk Railway.

Mr. Chamberlin's statement is devoted entirely to showing how the G.T.R. compares with other Canadian and United States railways from the standpoint of equipment and business done, and to pointing out that the twenty-one million dollars which the commission refers to as being required for maintenance, are not all deferred maintenance charges but partially deferred capital charges. Mr. Chamberlin's figures regarding the equipment of the road, business done and revenues received are no doubt correct, but there will be considerable wonder by the public as to why a road which has been doing so well should be in any way backward in its expenditures on either maintenance or capital account. Mr. Chamberlin shows operating revenues of $10,983 per mile, compared with $9,593 for the C.P.R. He shows 5,675 freight train miles per mile of line, compared with 3,511 for the C.P.R.; and also 2,322 passenger train miles per mile of line, compared with 1,399 for the C.P.R. If judgment is to be based on these figures alone, the Grand Trunk could well be expected to be richer than the Canadian Pacific.

Mr. Chamberlin says that only $13,104,998 is really the total of the deferred maintenance expenditures, and that the remaining $8,076,347 of the $21,181,345 quoted by the commission as being deferred maintenance charges, should really be considered as deferred capital expenditures. Of the $13,104,998 which he himself calls deferred maintenance expenditures, $11,761,598 are for maintenance of way renewals, and even of this sum Mr. Chamberlin says that $1,846,900 are truly capital expenditures, being for tie plates, rail anchors and farm tile in cuts.

It is to be hoped sincerely that the railway commissioners are wrong and that Mr. Chamberlin is right in these matters. Everyone in Canada will rejoice if these facts are correct. The fewer deferred renewals the G.T.R. has, the better for the country. If the G.T.R. can take care of its renewals, and has sufficient command of capital to make the necessary improvements, and meet all its obligations, the government should allow it to be continued as a private road. But Mr. Chamberlin does not show how he intends to catch up even on the $13,104,998 of deferred maintenance charges; and he passes very lightly over the main item of the thirty-million-dollar capital expenditure said to be required (namely, twenty-six million dollars for rolling stock, shops and machinery); and he ignores entirely the obligations of the G.T.R. to the people in respect to the G.T.P. The only phases of the report to which Mr. Chamberlin really offers an apparently adequate reply are two charges, (*a*) that the Grand Trunk's freight-carrying efficiency has greatly decreased, and, (*b*) that the Intercolonial has not been properly served at the Montreal terminal.

Mr. Chamberlin was examined under oath by the commissioners at Montreal on February 24th, 1917. The report of the commissioners includes extracts from the shorthand report of that examination. Mr. Chamberlin then said in part:—

"We can no more carry out that contract with the government than anything in the world. * * * The fact is that the Grand Trunk is not able to contribute anything toward paying its own security holders and making the improvements the people of Canada demand and the business of Canada require. * * * We would not likely have paid any dividends last year if we had paid out all on the Grand Trunk that we ought to have paid for betterments. We have not put in any rails for two years past, of any account. * * * I bought about 10,000 cars the first year I was here. They were all charged to capital account. We should have had a reserve fund for taking care of them. We now have to go and do the same thing over again. * * * If we had twenty-five million dollars now, it would put us in fine shape. * * * That is one reason I am fighting so hard for that twenty-five million dollars. I want to spend it here on the Grand Trunk. * * * I do not mean to say that the rails are dangerous. But we must put in a certain percentage every year. If we go for a couple of years, the first thing we know we will have a lot of rotten rails."

It is not easy to reconcile this evidence with Mr. Chamberlin's public statement. Nevertheless, the fullest consideration should be given to Mr. Chamberlin's statement by the government and by the railway commission; and as this is a subject upon which the public should be fully informed, so that public opinion may be correctly shaped, the Railway Inquiry Commissioners might very properly issue a later statement that would make any amendments to their previous report such as might appear advisable in the light of the facts brought out by Mr. Chamberlin's latest statement.

And the Canadian Northern System is yet to be heard from. If the heads of that railroad have any exceptions to make to the commission's report, it would be well for them to take the public into their confidence and to issue a frank statement of their position just as has been done by Mr. Chamberlin.

FOREIGN TRADE.

The growth of our foreign trade during the past few years has led many to believe that this business will be retained after the war. Most of the foreign trade we are getting now however, is being given to us.

After the war, with every nation keen to obtain new business, we will have to go into foreign markets and get

it in the face of keen competition. Canadian manufacturers have refused substantial peace orders, being too busy on war orders. Those manufacturers whose machinery is turning out war products probably recognize the necessity of finding employment for many of their machinists upon an output for normal markets. They will meet new competition in the lines they manufactured prior to the war, competition which has crept in while they were refusing orders.

Foreign trade, presenting certain difficulties which were duly solved, will present new difficulties, less easy of solution, in the light of competition. Favorable factors, which we cannot foresee now, may help the Canadian manufacturer after the war, but the man who is planning for that period will benefit his workmen, his country and himself.

PERSONAL.

F. F. BACKUS has been promoted to the position of general manager of the Toronto, Hamilton and Buffalo Railway. His former position, that of assistant to the president, has been abolished.

Lieut. THOMAS RUSSEL BUCHANAN, B.A.Sc., University of Toronto, 1913, has been wounded in action. He is a graduate of the mining section and went to the front with the Engineers in 1916. He was born in Thessalon, Ont., 26 years ago.

M. J. BUTLER, LL.B., C.M.G., of Montreal, past president of the Canadian Society of Civil Engineers, and D. H. McDOUGALL, M.Can.Soc.C.E., general manager, Dominion Steel Corporation, Sydney, N.S., received the honorary degree of LL.D. at the commencement exercises of St. Francois Xavier University, Antigonish, N.S., held on May 15th.

Lieut. GORDON PARSONS DAVIDSON, of Toronto, a graduate of the School of Practical Science, 1915, has been missing since May 3, and is believed to have fallen in action. Lieut. Davidson enlisted in a Toronto battery in October, 1915. Within a short time he had risen to the rank of sergeant, and in February, 1916, was selected as one of the University graduates for the draft which went overseas to receive commissions in the Imperial forces. After taking his course at Shorncliffe and Oxford, he was attached to the Royal Scots Fusiliers. Lieut. Davidson is 24 years of age and at the time of enlistment he was in the employ of A. H. Winter Joyner, Limited, Toronto.

Lieut. W. H. R. GOULD, Uxbridge, Ont., an honor graduate, in electrical engineering, of Toronto University, left for England on April 25, to join the Royal Naval Air Service. He received his lieutenant's certificate at Niagara Camp in the summer of 1915 with the C.O.T.C. Since graduation he has been superintendent of the Uxbridge electric light plant.

N. E. GUTELIUS, who has been resident engineer of the Brownville Division of the C.P.R. for the past two years, has been transferred to a similar position at Sudbury, Ont. His successor at Brownville is A. O. WOLFF, formerly resident engineer of the C.P.R. at Chapleau, Ont.

W. M. HUNTER, of Toronto, has been recommended by the Board of Control of London, Ont., for the position of superintendent of the asphalt department of that city.

W. D. JACOWAY has been appointed superintendent of the open-hearth and electric furnace departments at the new plant of Armstrong, Whitworth of Canada, Limited, at Longueuil, near Montreal. For some time Mr. Jacoway was connected with the open-hearth department of the Dominion Iron & Steel Co., Sydney, N.S., and later was with the Bethlehem Steel Co. at South Bethlehem.

Gunner ROGER ALLAN MACDONALD, B.A.Sc., University of Toronto, of Stratford, Ont., has been wounded and is reported seriously ill, suffering from a gunshot wound in the head. Gunner Macdonald enlisted over a year ago with the 54th Battery in Toronto and had been serving with the 6th Battery at the front for several months.

Dr. GEORGE G. NASMITH, C.M.G., Director of Laboratories, Health Department, Toronto, was admitted to the degree of Doctor of Science at the annual convocation of the University of Toronto, held on May 18th. The degree had been deferred since last year owing to the absence of Dr. Nasmith at the front.

Capt. GEORGE LAWTON RIDOUT, only son of Mr. Geo. Ridout, Toronto, was mentioned for gallantry in General Haig's despatch. He went overseas in the first contingent as a lieutenant in the Canadian Engineers, but was later transferred to the Royal Engineers, and promoted to a captain's rank. He is 29 years of age and before enlisting was engaged in engineering work. He was graduated from the Royal Military College, Kingston, in 1907.

Capt. C. JAMES SWIFT, of Kingston, Ont., who for five years was resident engineer of the Transcontinental Railway, and at the time of enlistment was an engineer on the Welland Canal, has been reported seriously wounded. He went overseas in May, 1915. He was graduated from the Royal Military College, Kingston, in 1908, and is a junior member of the Canadian Society of Civil Engineers.

Flight Lieut. M. B. WATSON, of Toronto, a graduate of the School of Applied Science, who enlisted at the beginning of the war with the Canadian Engineers, and who transferred to the Royal Engineers and subsequently to the Royal Flying Corps, has returned home for the purpose of helping with the training in Canada.

OBITUARY.

Major HOWARD CHURCH SYMMES, a graduate in science, McGill University, 1897, was killed in action while serving with the South African Infantry. After going through the South African campaign with the artillery from Guelph, Ont., he was employed as an electrical engineer in the Bureau of Mines at Johannesburg. He was a son of the late Mr. T. Symmes, of Aylmer, P.Q.

ALMOND PENFIELD TURNER, formerly president of the Canadian Copper Company, a subsidiary of the International Nickel Company, passed away at his home in Oakville on May 18th at the age of 52. The late Mr. Turner spent most of his life in Cleveland, but was in Copper Cliff, Ont., for ten years, joining the company in a junior position and rising to the presidency. He retired five years ago on account of ill-health.

A. R. WILLIAMS, president of the A. R. Williams Machinery Company, Limited, Toronto, passed away at his home on May 18th following a stroke of paralysis. Mr. Williams, who was in his 79th year, was born in Troy, Pennsylvania.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Report on Enlargement of Montreal Aqueduct

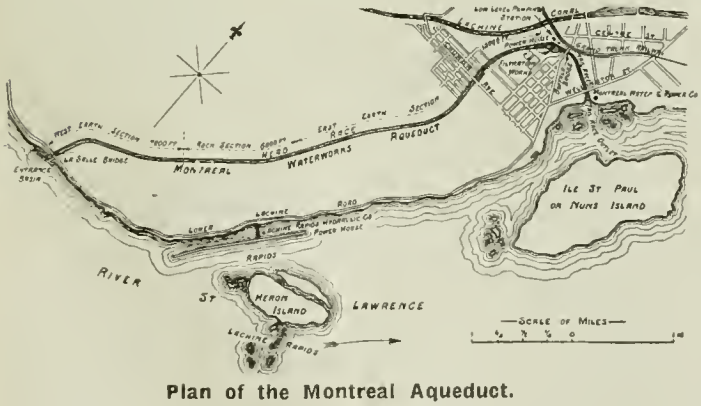
H. E. Vautelet, Arthur St. Laurent and J. B. McRae Discuss Merits of Five Different Schemes Suggested as Solution of Montreal's Civic Power Development Troubles—Review of Project as Designed—Status of the Work

MESSRS. H. E. Vautelet, Arthur St. Laurent and J. B. McRae, who were appointed last fall by the city of Montreal as consulting engineers to report on the aqueduct enlargement and civic power development scheme, presented the following report to the city commissioners and councillors, under date of April 30th, 1917:—

We, the undersigned, by virtue of the duties assigned to us, by a resolution of your board, passed on 6th February, 1917, have the honor to present herewith, our report on the city aqueduct and proposed power development.

To avoid any misunderstanding regarding the report of the ratepaying engineers on the Montreal Aqueduct, addressed to you on November 20th, 1916, we quote from a letter received from Mr. Walter J. Francis, secretary of the committee of ratepaying engineers, on April 24th, 1917:—

"I am instructed to write you to express our regret that a certain erroneous impression seems to prevail regarding the efforts and conclusions of the ratepaying engineers of the city. This is a matter which you will doubtless remember was discussed with you when we last met, and we would merely repeat at this time that our whole object has always been to have the project submitted to an independent board of engineers. The studies which were forced upon us resulted in our concluding (in conclusions 16 and 22) that 'all thought of completing the work *along the present lines* should be abandoned' and that the best should be made of what has been done, by

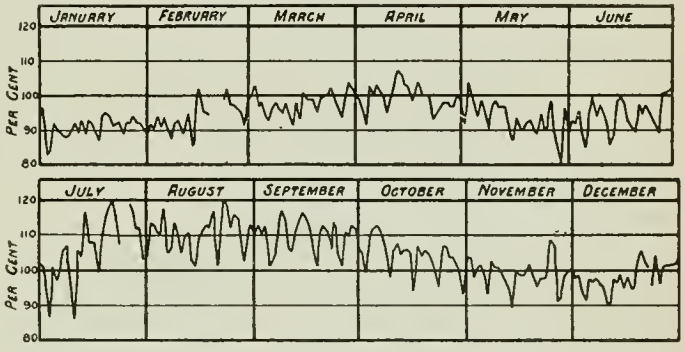


Plan of the Montreal Aqueduct.

the utilization and judicious adaptation of the present conditions. We never advised the complete abandonment of the work, and our references to the abandonment were hypothetical and made for the purpose of indicating the need of the investigation which we have demanded.

"I am instructed to say, on behalf of the ratepaying engineers that, in justice to them we confidently expect you will take occasion in your report, to correct the erroneous impression that complete abandonment was recommended, as stated in the daily press, and, indeed, even mentioned in the preamble of the official resolution appointing your board."

We do not consider it necessary to present here a full history of the aqueduct development since its inception, nor do we consider that we are called upon to do so, in view of the numerous reports already made to the city containing complete historical information on the subject.



Water Consumption Data.

Diagram showing daily pumpage as percentage of yearly average. Compiled from records of low level pumping station. Yearly average, 54,625,462 Imperial gallons=100%. Hourly pumpage varies 35% above yearly average.

It is, however, desirable, before commencing the discussion of the project, in accordance with the abovementioned resolution, to give a brief outline of the undertaking under progress, its present status as to the amount of work already performed, and expenditure in connection therewith.

Present Project.—The project in course of execution following previous enlargements, consists in the development of the present aqueduct to such dimensions and flow capacity as will enable the hydraulic development of 10,000 h.p. for the purpose of providing electrical horsepower for pumping the water supply needed by the city and for street lighting. It will also supply the water for the city's fire and domestic services.

Before commencing these later enlargements, a lateral concrete conduit of a maximum capacity of 75,000,000 Imperial gallons per day was built to insure a continuous water supply for the city. A filtration plant with a daily capacity of 50,000,000 Imperial gallons has been also built which it is intended, we are informed, to enlarge to a capacity of 100,000,000 Imperial gallons per day. The present aqueduct course is followed in its entire length in the scheme of enlargement.

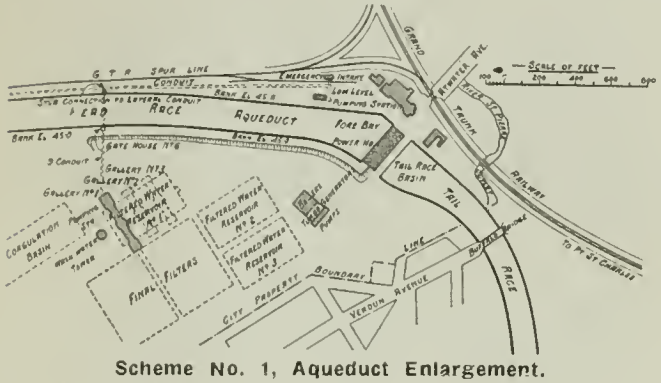
The intake is situated on the St. Lawrence River about one and one-half miles below the Canadian Pacific Railway Co.'s bridge, and the headrace or canal extends to the present waterworks station, a distance of 5.2 miles, where it is proposed to construct the necessary power house, for which no designs have as yet been made.

The headrace has a slope of 3.3 feet for the entire distance, and a bottom width of 103.85 feet. It runs partly in earth and partly in rock material. The bottom elevation at entrance is 21 feet above city datum. The water surface fluctuates from elevation 36 to 43.

The tailrace, which extends from the present waterworks to the St. Lawrence River, opposite Nun's Island, has a total length of about 3,300 feet, a slope of 4 feet, and a bottom width of 113.85 feet. The tailrace excavation will be apparently entirely through earth material. Elevation of the bed at the outlet is 2 feet above city datum. The water surface fluctuates from elevation 8 to 20; flood level has been as high as elevation 28.0.

Both sides of the entrance canal, forebay and tailrace are lined with concrete retaining walls. No paving is provided for the earth sections of the head canal. Paving for the bottom of the tailrace is provided for in the present contract only for the basin below the power house, but we are informed that it is intended to pave the whole of the tailrace, and this paving will, therefore, be considered as part of the present scheme.

Status of Present Work of Enlargement.—The city engineer, in a report to the board of commissioners, dated December 16th, 1916, estimates the total cost of the work, when completed, at $11,600,537.06 including cost of the work performed up to November 28th, 1916, covering all



Scheme No. 1, Aqueduct Enlargement.

Gallery No. 1, Filtration Plant as it is built. Gallery No. 2, proposed extension for 100 M. I. G. Gallery No. 3, proposed extension for 150 M. I. G.

contracts and expenditure since the beginning of the enlargements.

By deducting from the above the total amount of the cost of filtration works, the cost of a pump built in 1908-10 and interest thereon, not chargeable to cost of power development proper, the city engineer arrives at the following figures for the power scheme:—

Cost of work done to November 28th, 1916, including interest	$4,013,510.12
Estimated cost of work yet to be done, including interest	5,581,647.48
Total	$9,595,157.60

The amount of interest included in the total is $1,404,550.

The cost of abandoning the work has been estimated by Mr. Mercier as follows:—

Work done and interest	$4,013,510.12
Work to be done, or payment to make:—	
Bridges and fences	300,000.00
10% on balance of Cook's contract	203,640.00
Power house and building to use the 7,000 h.p. purchased	340,000.00
Construction of another conduit or protection work	1,000,000.00
Total	$5,857,150.12

This is exclusive of large claims against the city in connection with this work, and which will require adjustment.

Work Performed.—The present condition of the work for the entire aqueduct is as follows:—

Earth excavation	About 50% done
Rock excavation	" 90% "
Retaining wall, north side of entrance canal	48% "
Retaining wall, south side of entrance canal	20% "
Forebay and tailrace walls	Nil
Power house	"
Entrance gates, contract yet to be awarded	No work done
Supply conduit	100% done
Expropriations of land required for boulevards, etc.	Not completed

The result of our studies is presented under the following main headings, with such subdivisions of each subject as are necessary for a clear understanding:—

1. Method followed in carrying out the investigation.
2. Frazil.
3. Consumption of water by city.
4. Power actually used for pumping and lighting, and future requirements for pumping and lighting.
5. Definition of the term "horse-power."
6. Project as designed; hydraulic data; velocities.
7. Amount to be spent if work is now abandoned.
8. Scheme No. 1, present scheme.
9. Scheme No. 2, maximum power available.
10. Scheme No. 3, minimum power available.
11. Scheme No. 4, pumping by steam.
12. Scheme No. 5, buying electric current.
13. Lighting.
14. Total cost and cost of operation of all schemes.
15. Financial statement.
16. Remarks on cost.
17. Recommendations.

Method Followed in Carrying Out the Investigation. The needs of the city are as follows:—

Power for pumping water at Atwater Avenue, and electric current for water pumping stations such as McTavish Street and Papineau Avenue, sewage pumping stations, filtration works and street lighting.

There are three ways of obtaining the needed power:—

1. The establishment of a hydro power station at Atwater Avenue (Schemes 1, 2 and 3).

2. Pumping by steam and buying electric current for other needs (Scheme 4).

3. Buying electric current for all the needs of the city (Scheme 5).

A start has been made towards the carrying out of Scheme 1, and the adoption of either Scheme 4 or 5 would necessitate discontinuing the works now in course of execution. We, therefore, had to estimate the cost of making the canal fit for such services as may be required.

If the work be discontinued we have to consider two cases, A and B. In case A (Scheme 4 and 5) the banks of the canal, where walls have not been built, are simply trimmed to a natural slope, without any attempt to secure straight side lines or regular curves, cutting down the expenditure for this purpose as low as possible, leaving the tailrace in its present state.

In case B (Scheme 3), to develop power, the banks of the canal are sloped in straight lines and regular curves to ease off the flow, and the tailrace is enlarged to accommodate the discharge through the headrace.

The cost of case A was found to be $5,895,000 and the amount of interest charged amounts to $1,072,948.

This amount of $5,895,000 has, therefore, to be added to the cost of pumping by steam or by electric current.

If the work is proceeded with, we had again to consider two cases; Case C, connecting the pumps directly to some of the turbines in the power house, and case D, using all the power from the power house to produce electric current, and then using part of the current to operate motor-driven pumps.

The question of connecting the pumps direct to the water-wheels was considered, but on account of the low available head and the resultant slow speed of the turbines, it was found advantageous to operate direct-connected generators in the power house, using the electric power so generated to operate motor-driven pumps. This scheme not only simplifies the design of the pumping units and their connections, but provides a most flexible plant. For example, every turbine unit is available at all times, that it is possible to operate, for either furnishing power for pumping purposes, or any other electric power service required. In the case where the turbine is direct connected to the pump, then that turbine can be used for pumping purposes only.

As the power house at times will not be in operation on account of frazil, high water, etc., and as there is a large difference between summer and winter power, it was also necessary to consider the case of providing an auxiliary steam plant.

We, therefore, calculated the capital cost, cost of maintenance, and cost of operation of the following:—

Canal and tailrace; hydro-electric power house; auxiliary steam electric plant; pump house, operated electrically; stand-by steam pumping plant.

As will be seen, it was found cheaper to discard entirely the old steam pumping plant and build a new one, and finally it was found advantageous to discard this new plant altogether, and enlarge the auxiliary steam electric plant for all requirements.

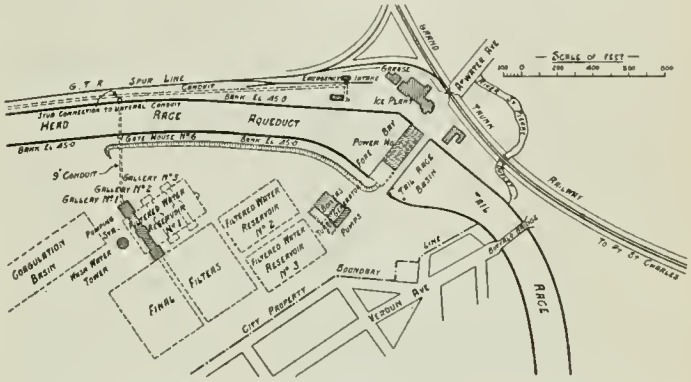
We first calculated the cost of the canal and tailrace as projected (Scheme 1) and the results of our studies, owing to uncertainty due to the nature of the bottom of the canal to resist scouring and the tendency of the retaining walls to slide, led us to calculate the cost of the maximum possible development of power from the canal with paved bottom and maximum enlargement of the tailrace (Scheme 2).

Filtration Works.—The filtration works were built for a capacity of 50 million Imperial gallons per day but are not yet in operation. The average daily quantity of water pumped last year was 54½ million Imperial gallons, running for some periods of three hours, at a maximum rate of 73 million Imperial gallons. The filtration plant as built would, therefore, be insufficient for the present requirements of the city, and either it would have to be worked much above its normal capacity or a mixture of filtered and unfiltered water would have to be used. Both conditions are undesirable, and such a situation should be avoided.

Bridges.—Under the present plans it is contemplated to build eleven bridges over the tailrace and canal, *viz.*:—

	Name.	Location.		Name.	Location.
1.	Wellington	Tailrace	7.	Asylum	Sta. 124.75
2.	Buffalo	Tailrace	8.	Crawford	Sta. 135.50
3.	Filtration	Sta. 14.00	9.	Knox	Sta. 190.10
4.	Church	Sta. 41.80	10.	Latour	Sta. 231.60
5.	Woodland	Sta. 81.30	11.	Lasalle	Sta. 269.39
6.	Location not decided.				

The cost would be the same in all cases, except for Scheme 2, when the Wellington and Buffalo bridges would have to be longer owing to the widening of the tailrace.



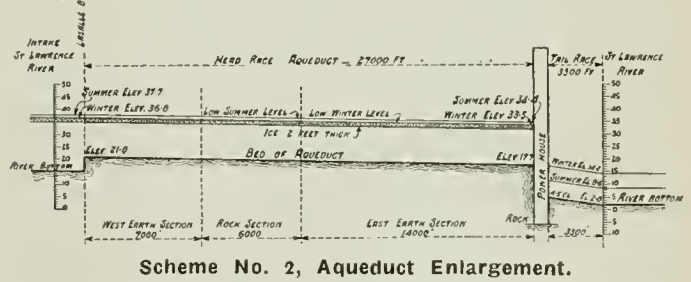
Scheme No. 2, Aqueduct Enlargement.

Gallery No. 1, Filtration Plant as it is built. Gallery No. 2, proposed extension for 100 M. I. G. Gallery No. 3, proposed extension for 150 M. I. G.

The head-gates of the canal are a part of the Lasalle bridge.

We have therefore left out the cost of 10 bridges in Schemes 1, 3, 4 and 5, but have included the cost of Lasalle bridge in all schemes. We have also added to Scheme 2 the cost of the Wellington and Buffalo bridges. Riprapping at other bridges than Lasalle may possibly be needed for all schemes, but its cost has been added to Scheme 2.

The riprapping we have figured upon, around the bridge piers in the canal, extends down stream for 100 feet from the head of the piers and for the whole width of the aqueduct. The bottom of the canal, where it is in earth, is excavated for a depth of 6 feet or to rock, if the rock is



Scheme No. 2, Aqueduct Enlargement.

less than 6 feet from the bottom of the canal. Five feet in depth is filled up with large and small stones and clay puddle, over which is laid one foot of good concrete.

Boulevards.—The cost of land for boulevards has been included only in Schemes 1 and 2. Owing to the grading of slopes in Schemes 3, 4 and 5, part of the land needed for boulevards is used for the banks, and the balance, becoming useless, has been omitted.

We cannot estimate in dollars and cents the value of the boulevards. Whatever value the boulevards may have to the city is beyond the scope of this report.

It must, therefore, be understood that there is no land for boulevards in Schemes 3, 4 and 5 and that in Schemes 1 and 2 we have included the cost of land for boulevards, and whatever grading and filling are included in Cook's contract and nothing else.

Contractors' Claims.—These being the same for all five cases, have not been included.

Frazil.—Messrs. Ernest Marceau and John Kennedy, in their report, dated May 6th, 1907, addressed to Mr. Frank Dowd, secretary of the water committee of the city of Montreal, say in their last paragraph:—

"The details of the works at the entrance of the aqueduct and the intake of the conduit are not yet fully worked out, but from the fact that the position of the present aqueduct intake is a very favorable one, and that no trouble has ever been experienced from frazil entering it, we are of the opinion that the works can be so designed and built, that their operation will not be seriously interfered with by frazil."

Mr. F. Clifford Smith, in his official history, "The Montreal Water Works, 1913," page 35, quotes Messrs. J. H. Harrington and Thos. L. Hickey, as follows:

"We have given considerable attention to the question of whether or not the frazil or slush ice would make any complications as regards the entrance of the river water through submerged ports, protected by wooden slats or screens. A considerable number of personal observations by Messrs. Janin and Lesage have been made by holding a screen in the water in this vicinity at times when frazil is known to occur at other places. Available data indicate the comparative absence of complications as to frazil. In recommending the construction of an intake 1,200 feet from shore, we beg to state that we have considered this matter with respect to the purification of the supply. Taking everything into consideration, we are convinced, as above stated, that it will be wise to carry out Mr. Janin's recommendations for the outer intake."

The ratepaying engineers, in their report of 1916, paragraph 7, say:—

"Serious operating troubles, due to frazil and other ice, are inevitable. These will greatly reduce the maximum output below 7,000 horse-power and may cause complete stoppage of the plant during a more or less protracted period every winter."

These opinions are from high authorities who are better acquainted than we are with the conditions at the entrance of the aqueduct.

The engineers who have studied and recommended the enlargement of the aqueduct have provided for a long extension of the cribwork at the entrance, to prevent the formation and admission of frazil. We have omitted the cost of this cribwork, as it may be built after the works have been in operation and conditions studied.

It is certain that frazil and anchor ice will give trouble, and to the best of our knowledge there is no way to prevent same. We have, therefore, provided for an auxiliary steam plant to furnish power during times of ice trouble. For the purpose of estimating, we have assumed that on the average there will be a decrease in hydraulic power equivalent to a complete shut-down of 2.4 months each year.

Dredging.—Any dredging needed for Schemes 1, 2 and 3, at outlet of tailrace, has been provided for in our estimates.

Consumption of Water by City.—The average quantities per day of water pumped during the years 1903-1913 are shown on the table at the top of the next page. The percentage of increases are also shown.

Present and Future Power Required for Pumping and Lighting by City of Montreal

Power actually used by city, pumping 60 million Imperial gallons per day, and for lighting.

Description.	Pump'g.	Light'g.	Totals.
Pumping, Atwater Avenue ...	4,710	....	....
Filtration, Atwater Avenue ...	2,960	....	....
Total	7,670	....	....
Electric pumps	2,000	....	....
Total for water supply ...	9,670	....	....
Sewers	520	....	....
Total pumping for city of Montreal	10,190	....	....
Lighting city	....	2,890	....
Total pumping & lighting	....	....	13,080
Montreal W. & P. Co. System	5,600	....	....
Outremont, Westmount, Maisonneuve, Verdun	....	1,064	....
Total for pumping city and Montreal W. & P. Co. systems	15,790	....	15,790
Total for lighting	....	3,954	3,954
Total horse-power	....	....	19,744
			say, 20,000 h.p.

Power needed in near future, pumping 100 million Imperial gallons per day, and for lighting.

Description.	Pump'g.	Light'g.	Totals.
Pumping, Atwater Avenue ...	8,570	....	....
Filtration, Atwater Avenue ...	3,270	....	....
Total	11,840	....	....
Electric pumps	2,500	....	....
Total for water supply...	14,340	....	....
Sewers	520	....	....
Total pumping for city of Montreal	14,860	....	....
Lighting city	....	4,330	....
Total pumping & lighting	....	....	19,190
Montreal W. & P. Co. System	8,960	....	....
Outremont, Westmount, Maisonneuve, Verdun	....	1,600	....
Total for pumping city and Montreal W. & P. Co. systems	23,820	....	23,820
Total for lighting	....	5,930	5,930
Total horse-power	....	....	29,750
			say, 30,000 h.p.

Table Showing Increases in Consumption of Water at Montreal

Year.	Million Imp. gals.	Percentage of increase.
1903	24.5	
1904	27.7	13.0% over 1903
1905	30.1	9.0% " 1904
1906	31.7	5.5% " 1905
1907	34.0	7.2% " 1906
1908	35.7	5.0% " 1907
1909	36.7	5.5% " 1908
1910	38.6	5.2% " 1909
1911	42.8	10.9% " 1910
1912	47.3	10.5% " 1911
1913	52.0	9.5% " 1912

In 1916 the average quantity of water pumped per day was 54,625,462 Imperial gallons. The percentage of increase in the water consumption between 1903 and 1913 is 112%, and the percentage between 1904 and 1913 is 88%.

Our calculations are based on an increase of 86% above the quantity of water pumped last year, and we have estimated that such an increase will take place in from 5 to 10 years.

It is this increased quantity we have called the "future needs of the city."

Power Actually Used for Pumping and Lighting and Future Requirements.—From the information we have been able to obtain, we give, in the tables at the bottom of page 454, the amount of power actually used for pumping and lighting by the city and the adjacent municipalities of Outremont, Westmount, Maisonneuve and Verdun, including the power needed for the filtration plant as now built.

Considering the rate of increase in the consumption of power which has taken place during the last ten years, we have also estimated the probable needs of the city and adjacent municipalities for the near future, say, within the next five or ten years. This is also in the statement below. It will be seen that the city and surrounding municipalities mentioned above, now use practically 20,000 h.p. for pumping and lighting, and that the requirements for the near future will not be less than 30,000 h.p.

Definition of the Term "Horse-power."—To avoid misconception of the term "horse-power" in our report, the letters h.p. represent the horse-power or energy due to falling water without any losses.

As this water passes through turbines and puts machinery in motion, to be transformed into electrical energy and sent over distribution lines to do useful work, some of the original energy is lost step by step, and all our calculations are based on the following table of efficiencies in horse-power for pumping and lighting.

The electrical horse-power available at the power house, or delivered according to present contract at 2,200 volts, will be indicated by e.h.p., and for the power delivered at other places, the name of the place will precede the letters h.p. and e.h.p. (See tables of efficiencies at the bottom of this page.)

Project as Designed.—We are indebted to the chief engineer of the city and his staff for copies of all documents and hydraulic data bearing on the Montreal aqueduct. These studies are exceedingly well made and have been found to be correct in agreement with assumptions made.

We cannot consider, however, as permissible, the high velocities assumed for the headrace, and we differ somewhat as to the co-efficient for retardation of flow due to the character of the canal bottom, factors which affect the quantity of power to be derived from the development.

In the information given it is stated that the flow in the canal has been obtained by means of the Kutter formula, assuming a slope of 3.3 in 27,000 feet, and a value of 0.02 for the co-efficient "n" (earthen channel in good order). The same co-efficient of 0.02 has evidently been assumed for the upper surface of the water when covered with surface ice.

Tables Showing Lighting and Pumping Efficiencies in Percentages of Water Horse-Power

LIGHTING.

Item.	Efficiency.	Overall efficiency.
Power at fall	100%	100%
Turbine	82%	82%
Generator	93%	76.26%
Outgoing lines	98%	74.73, say 75%
Lines to central distributing station	91%	68%
Rectifier	92%	62.6, say 62%
Line	96.8%	60.6, say 60%
Switchboard, power house to lamp	$\frac{60.6\%}{74.73}$ =	81%
Switchboard, main distributing station to lamp	$\frac{60.6\%}{68\%}$ =	89%

Efficiencies differ according to the machinery employed to transform the energy of falling water, and the above table is given only to show the value of the efficiencies which we have used in our calculations.

PUMPING.

Low Level Pumping, Atwater Avenue.

Power house switchboard	75%	
Motors	90%	67.5%
Pumps	80%	54%
Filtration plant, efficiency transformer and line	96% × 75%	72%

High Level Pump Efficiency, McTavish Reservoir. Smaller Units.

Motor and pump	68.8%, say 69%	
Efficiency at switchboard	68%	47%

Papineau Avenue Pump Efficiency.

Motor and pumps	64.4%
Efficiency at switchboard	68%, say 44%

From this table it follows that:—

To produce:	Requires:
1 e.h.p.	1⅓ h.p.
1 lamp h.p., 746 watts	1⅔ h.p.
1 pump h.p. at Atwater Avenue	1.85 h.p. or 1.39 e.h.p.
1 pump h.p. at McTavish Res'voir	2.13 h.p. or 1.60 e.h.p.
1 pump h.p. at Papineau Avenue	2.28 h.p. or 1.71 e.h.p.

The ratepaying engineers, we are informed, assumed a higher co-efficient of roughness for their calculations of flow, and adopted a value of $n = 0.03$ as more correct, in their opinion, to meet the conditions of the canal, particularly that section which is in the rock cut, the effect being to give somewhat lower values in flow capacity.

After having given consideration to all the conditions affecting this factor, and examined the bottom and sides of the canal, we have come to the conclusion that co-efficient $n = 0.025$ is best suited to the conditions of the canal.

The canal is assumed to be covered with two feet of ice for winter conditions. It is also assumed that the hydraulic gradient is parallel to the bed of the canal, making the depth of water uniform; in other words, the difference in level or friction head between the entrance of the canal and the forebay, *viz.*, 3.3 feet, is totally absorbed in cases of maximum flow to produce motion or induce the water to flow in the canal.

When the turbines, however, take only a percentage of the natural flow, then only a percentage of the total friction head is absorbed.

Probably one of the most critical questions to be considered, which affects mostly, in this case, the amount of energy to be obtained from the development, is the question of permissible velocities as governed by the character of the bottom and sides in both the headrace and tailrace.

We are informed that the tailrace will be paved, thus permitting of velocities as high as 8 or 10 feet per second (5.46 to 6.82 miles per hour).

The bed of the headrace, for a large proportion of its length, is of such a character as will permit only of a very low flow velocity, in order to prevent scour and danger to the walls. On this account we have looked with particular care into the question of limiting velocities for the project as designed.

Velocities.—The principal elements of a water power development are, the sectional area of the power canal, the permissible velocity of flow due to the material through which the canal is built so as to prevent all danger of scouring, the amount of water available and the net head.

For the project under execution we may say that the supply of water is practically unlimited. The section of the headrace or canal may be said to be fixed; that is, it cannot be further enlarged without great and unreasonable cost, on account of the large percentage of the side-walls already built, and it must remain the governing factor as to amount of water available to produce power, assuming an adequate enlargement of the tailrace where no work has yet been done.

The capacity of the canal is, in turn, necessarily dependent on the maximum velocity which can be permitted on the earth bottom sections of the canal, side concrete walls being provided under existing contracts.

We have given the most serious consideration to this question, and comparative studies have been made to determine the resulting flow and power, considering the nature of the material forming the bottom of the present canal, and also a concrete paved bottom.

Taking first the case of development under the present plans, we find the following reference to the nature of the material, in the report dated February 21st, 1914, of Messrs. J. A. Jamieson, R. S. Lea and G. R. Heckle, on the Montreal water supply conduit:—

The soil through which the aqueduct is being excavated, and in which the conduit is embedded for the greater part of its length, is largely composed of boulder

(Continued on page 470.)

MONTREAL WATER AND POWER COMPANY'S CHLORINE CELL INSTALLATION.*

By Frank Henry Pitcher, M.A.Sc.,
General Manager, Montreal Water & Power Co.
and James O. Meadows, A.M.Can.Soc.C.E.,
Chief Chemist, Montreal Water & Power Co.

THE sterilization of public water supplies with chlorine or chlorine compounds, either as an adjunct of filtration or as a sole method of purification, is now standard practice and this method is well understood, but the production of electrolytic chlorine and the application of the gas so produced to the water to be purified, is of rather recent date, and except in a general way is but little understood by the waterworks fraternity.

The electrolytic cell installation of the Montreal Water & Power Co. has been in service since the first part of the present year, a period hardly long enough from which to gather average operating results, but during the time that the plant has been in service considerable information and data has been secured that is of interest.

Historical Sketch.—The fact that the common salt can be broken down or decomposed into its elements, sodium and chlorine, by electrolysis, has been known practically since the discovery of the galvanic cell, but the commercial application of this principal was impossible until many difficulties had to be overcome to perfect an electrolyzing equipment which would efficiently and effectually separate the products and at the same time withstand the corrosive action of the chlorine gas.

Numerous types of electrolytic cells, or decomposing chambers, have been evolved and perfected to a degree, but only a few have been even a partial success commercially.

In its simplest form an electrolytic cell is a tank or chamber, composed of materials that will resist chlorine, and containing brine in which a positive and negative electrode is immersed. Upon the passage of an electric current through the cell, chlorine gas is liberated at the positive electrode, or the anode, and simultaneously metallic sodium is released at the negative electrode, or the cathode. This metallic sodium immediately combines with the water in the brine, forming caustic soda, and liberating hydrogen gas. The momentary products from the cell are, therefore, chlorine gas, a weak caustic solution, and hydrogen gas: but the chlorine gas and the caustic soda immediately combine to form sodium hypochlorite, or so-called sodium bleach.

Cells of exactly the type described have been and are now sold for laundry use, but they cannot be employed when a complete separation of the products is required. Furthermore, this type of cell can produce only a weak bleaching solution, and that inefficiently, because after the sodium hypochlorite reaches a certain strength, it is in turn decomposed by the electric current, making the process retroactive, with the damaging result that the oxygen in the sodium hypochlorite combines with the carbon of the anodes to form carbon dioxide gas.

From the foregoing it is obvious that to obtain a perfect cell for the production of chlorine gas, the chlorine and the caustic soda, which are the primary products of electrolysis, must be prevented from recombining. To

*Paper read before American Waterworks Association. May, 1917.

secure this separation of the products, four distinct lines of development have been followed:—

(1) By the insertion of a permeable diaphram between the anode and the cathode.

(2) By employing a mercury cathode which is alternately the cathode in the electrolyzing compartment of the cell and the anode in an adjoining compartment where the amalgam of metallic sodium and mercury is decomposed by water.

(3) By placing the cathode under the anode and depending upon the stratification of the electrolyte which occurs due to the different densities of the brine solution and the caustic solution surrounding the immersed cathode.

(4) By the use of a fused salt electrolyte and a molten lead cathode.

Only the diaphram and the mercury types survived commercial exploitation in this country on account of the inefficiency and cost of maintenance for the other types indicated above under items three and four.

The several forms of diaphram cells which have been commercially operated, consist of two groups:—

(*a*) Cells with submerged diaphrams and cathodes.

(*b*) Cells in which the electrolyte comes in contact with one face only of an unsubmerged diaphram.

Very early in the history of electrolysis, Le Sueur, Gibbs, Crocker, Nelson and others conceived and operated cells of the submerged diaphram, or first group. Le Sueur employed a horizontal diaphram and Gibbs employed a circular cell with a vertical diaphram.

The unsubmerged diaphram group is in turn subdivided into two classes,—with permeable and impermeable diaphrams.

All of the permeable diaphrams for both the unsubmerged and the submerged group of cells are composed of asbestos paper or cloth, disposed in the cell in such a manner that they separate it into two distinct compartments, designated (1) as the anode compartment, into which the saturated brine is introduced and where the chlorine is formed; and (2) the cathode compartment, where the caustic soda is formed.

With cells of the submerged diaphram group it is possible to a large extent to keep the chlorine gas and the caustic soda separated by maintaining a liquor level in the anode compartment higher than the level in the cathode compartment, thus inducing a continuous flow from the anode to the cathode chambers. Nevertheless, by osmotic action and mechanical interchange through the diaphram, the salt caustic liquor from the cathode compartments invades the anode compartment and there combines with the chlorine to form sodium hypochlorite, which results in the loss of these two products and causes a rapid disintegration of the anode, as previously noted in the description of the laundry cell.

Cells of the submerged diaphram type operate in practical service at not more than eighty-five per cent. current efficiency (excepting only the Billiter-Siemens cell), with a maintenance which is in direct ratio to their lack of efficiency; because, the less efficient the cell, the more hypochlorite is formed in the anode compartment, with the consequent shortening of the life of the anodes.

Cells of the submerged diaphram type operate with reasonable efficiency during the first few weeks of service after a new diaphram has been inserted, but as the age of the diaphram increases, it becomes less permeable and accordingly more effective as an osmotic vehicle for the contamination of the anode by the products of the cathode compartments.

With cells of the second group, having the diaphram immersed on one side only, the above-described contaminating influences are entirely eliminated, because there is no large body of caustic liquor present in the cathode compartments, since the cathode liquor is withdrawn as fast as it is formed. It follows that in actual service cells of this type closely approximate theoretical current efficiency, with a resulting increased output and a longer life than can possibly be attained by cells of the submerged diaphram type.

The Allen-Moore cell, as installed by the Montreal Water & Power Co., is of the unsubmerged diaphram type and is guaranteed to have a current efficiency of not less than ninty-two per cent.

Description of the Installation.—The chlorine cell installation consists of a salt storage bin (having a capacity of 40 tons of salt), the brine saturating and purifying equipment, two 15-h.p. motor generator sets, four chlorine cells and the silver ejectors and distributing lines for applying the chlorine water to the water to be treated.

The brine saturating and purifying equipment consists of three vertical galvanized iron saturators (twenty-seven inches in diameter by six and a half feet in height, provided with a spray system at the bottom and an outlet six inches from the top), and two concrete reaction tanks having a capacity of 82 cubic feet each. These tanks are built with sloping bottoms and are provided with a pipe grid for air agitation. Two sand filters are provided for filtering the purified brine which passes from the filters to the two concrete storage tanks, having a capacity of 276 cubic feet each.

The distributing lines for applying the chlorine water to the water to be treated are one-inch chemical hose lines, and the chlorine gas is ejected into the water by means of a silver ejector, which maintains a four-inch vacuum on the chlorine cells and takes the gas from the chlorine main through the ejector to the distributing lines.

Description of Chlorine Cell.—The four electrolytic cells are of the Allen-Moore type. Each cell is a standard 600-ampere unit and is 7 feet long by 20⅜ inches wide. Each cell is provided with Acheson graphite anode plates, and pure wrought iron perforated cathode plates. As stated previously, the Allen-Moore cell is of the unsubmerged diaphram type and uses asbestos paper for the diaphram material. Unlike several other types of electrolytic chlorine cells, the cell box of the Allen-Moore cell is made of concrete, properly protected at the surface to withstand the action of the chemicals.

The cells are connected in series and are provided with short-circuit switches or cut-outs. The voltage carried on each cell is approximately 3.3 volts, and each cell is capable of producing 32 pounds of chlorine per 24 hours.

Preparation of Brine Solution.—A small quantity of water under pressure is allowed to flow in the bottom of the saturators. The saturators being charged with salt, a saturated solution of salt is delivered to the two concrete reaction tanks. A sufficient quantity of soda ash is added to the brine in the reaction tanks to combine with the calcium and magnesium salts present in the brine, and the contents of the tanks are agitated for one-half hour to insure complete mixing of the soda ash solution with the brine, and also to hasten the reaction. The solution is then allowed to remain in a quiescent state for one hour to allow the precipitate formed to settle, when the solution is filtered through the sand filters into the purified brine storage tanks. A sample of the purified brine is

taken and titrated for residual alkalinity, which determines the amount of hydrochlorite acid necessary to add to neutralize the alkalinity and leave a residual acidity of about .01 per cent. It is necessary to have the electrolyte slightly acid to prevent the formation of hypochlorites within the cell, and the subsequent loss of cell efficiency.

Electrolytic Cell Efficiency.—The cell or current efficiency is computed from the cell flow of caustic liquor, the amount of caustic produced, and the current used to effect the dissociation. The flow of caustic liquor is measured for a certain period and computed as liters flow per hour, and at the same time a portion of the caustic liquor is titrated with normal acid to determine its strength. Knowing the flow per hour and the amount of caustic per litre, the number of grams of NaOH produced per hour can be easily determined, which figure is known as the actual caustic production.

The number of amperes passing through the cell, multiplied by 1.49 grams (theoretical NaOH production per hour per ampere) will give the theoretical caustic production; and this result, when used as the divisor, and the actual caustic production as the numerator, will give a product which when multiplied by 100 will be the percentage current efficiency of the cell. Also, as the amount of caustic produced is to the amount of chlorine produced as the atomic weight of NaOH is to the atomic weight of chlorine, the amount of chlorine produce can be easily determined. The amount of chlorine produced can also be determined by direct titration, and this chlorine assay will act as a check on the first determination. The operating current efficiency has so far been maintained at between 93 per cent. and 96 per cent.

Cost of Chlorine Production.—The annual cost of production is arrived at as follows:—

Salt @ $8 per ton	$ 500.00
Power @ $30 per h.p.	450.00
Interest at 6 per cent. on $5,000	300.00
Depreciation at 15 per cent.	750.00
Labor and superintendence	500.00
Total	$2,500.00

Three out of the four chlorine cells furnish the requisite amount of chlorine for sterilization, yielding 90 pounds of chlorine gas per 24 hours, or 32,850 pounds per year, making the cost of chlorine produced 7.6 cents per pound.

Comparison with Present Hypochlorite Cost.—The annual cost of sterilization previous to the installation of the chlorine cells was as follows:—

Chloride of lime at 3.75 cents per lb.	$4,105.00
Interest at 6 per cent.	150.00
Depreciation at 5 per cent.	125.00
Labor and superintendence	500.00
Total	$4,880.00

As the amount of chloride of lime required was 300 lbs. per day, or 100 lbs. of available chlorine, the cost per pound was 13.4 cents, or 5.8 cents per pound more than chlorine produced by the electrolytic cells.

With normal market conditions the annual cost of the two forms of treatment would be approximately the same, if one did not consider the general depreciation that chloride of lime causes about a water purification plant.

Operation of Chlorine Cells.—An electrolytic chlorine cell functions at its best when under a constant current load, and for this reason it is good practice not to vary the load; or, if varied, to bring about the change gradually. Variations in load cause a considerable deterioration of the diaphrams, with a consequent loss in cell efficiency. For this reason automatic control of the chlorine production from an electrolytic cell is not practical, and for the treatment of a large volume of water, without appreciable variations in volume, automatic control is not required, for the dosage can be regulated for the maximum requirements without causing tastes or odors during the minimum consumption periods. The three cells required to supply the chlorine consumed for sterilization are operated with a current load of 500 amperes and 13 volts. The electrolytic cells require very little attention, and to date have given excellent satisfaction.

Caustic Liquor.—The caustic liquor from the cells contains about 12 per cent. of sodium chloride and about 10 per cent. of NaOH. No recovery of the salt and caustic is attempted, because the amounts of these two chemicals produced is so relatively small that their recovery would not be economical. For large installations the recovery of the salt and caustic is a regular feature of the process, the salt recovered being used over again, and the caustic is concentrated and sold as liquid caustic.

Reasons for Adoption.—The chlorine cell installation was adopted because of the saving effected over the present high price of chloride of lime, because of inability to secure this chemical with any degree of certainty, and also because common salt is very much easier to handle around a water purification plant, and its use in the chlorine cells does not cause the general deterioration about the works that the use of chloride of lime does. Over-dosage with chlorine does not cause the trouble that chloride of lime over-dosage does, because odors and tastes are not present to the same degree.

The short experience at Montreal with chlorine cells for the sterilization of a public water supply, indicates that an installation of this kind is perfectly feasible for large water supplies where the cost of power is not excessive.

SECURED B.A.Sc. DEGREE.

As a result of the recent examinations of the School of Practical Science, Toronto, the following gentlemen may now write "B.A.Sc." after their names:—

Harold A. Babcock, Joseph Banigan, Albert E. Berry, Robert S. C. Bothwell, Frank C. Christie, James C. Colleran, Ellis H. Corman, John Van E. Dickson, Jonathan A. Fraser, William K. Greatrex, George Hanmer, Alfred B. Harris, Ralph W. Harris, Richard W. Hurlburt, Ludovic Levesque, Stewart G. McCandlish, Harold L. McClelland, Patrick E. McIlhargey, Ralph C. Manning, Alvan S. Mathers, John E. O'Brien, William A. R. Offerhaus, Harry A. Parr, Roswell D. Ratz, Ernest E. Smith, Arthur M. Snider, Rupert M. Speirs, Albert W. Swan, Arthur P. Thomson, Charles E. Tilston, Benjamin C. Tomlinson, Victor Topping, Alexander A. Tufford, Howell A. Tuttle, Edward J. Tyrrell, Harold R. Watson and George Wood.

The Canadian Electrical Association will hold a convention of all the members of the association at the Ritz-Carlton Hotel, Montreal, on June 7th and 8th. Secretary, Alan Sullivan.

Letters to the Editor

Railway Valuation Costs.

Sir,—I note in your issue of the 10th inst. a reference to the cost of valuations, in which you state that my recent work for the Commission of Inquiry into Railways and Transportation in Canada cost $3 per mile, which "compares with $240 per mile for the Interstate Commerce Commission's valuation of United States railroads, with $40 per mile for Prof. Swain's valuation of the New York Central Lines, and with $50 to $100 per mile for other valuations which have been made by him."

In order that there may be no misapprehension on the part of your readers, let me state that my report gave no figures with reference to cost of valuations. The cost of my work in Canada is, however, accurately stated by you.

Various estimates have been made of the cost of the valuation of United States railroads by the Interstate Commerce Commission, and one recent estimate, including the cost to the railroads, was at the rate of about $240 per mile. This estimate, however, may prove to be much exaggerated, as nobody knows as yet what the total cost will be, and I need not say that I, of course, assume no responsibility for it.

So far as I am informed, some other valuations of railroad properties have cost up to $75 or $100 per mile, but I have not authoritatively verified these figures, nor have I made any valuation of large properties myself which have cost over $50 per mile.

We should not prejudice the work of the Interstate Commerce Commission by publicly stating figures which may prove to be much exaggerated. The work of that commission, of course, is being done in great detail. Whether such great detail will result in greater accuracy of the final figure, considering the many inherent uncertainties in the problem, may be a question. I have in my library, for instance, reports on valuations in which the inventories are given in such detail that there are many items of $.01. Of course, in any valuation, it is a question how far the detail work should be carried, and there may be differing opinions as to this matter.

GEO. F. SWAIN, LL.D.

Cambridge, Mass., May 18th, 1917.

Montreal Paving Report.

Sir,—I note in your May 10th issue a review of our recent report on paving, made to the chief engineer of Montreal. It seems to us that the last paragraph, unintentionally we are sure, gives a somewhat erroneous impression of some points in the report. You say:—

"The report contains approximately fifteen thousand words and is very exhaustive, reviewing the whole field and offering a considerable number of valuable constructive criticisms, although there are some recommendations with which all engineers would not agree, particularly the recommendation that one type of pavement be adopted as the standard throughout the whole city, the statement that certain pavements previously laid in Montreal could not have proven economical 'had they lasted forever without repair or renewal,' and the recommendations regarding omission of the binder course."

It might be pointed out that our recommendation is that a "standard" be adopted and generally used, except in such places where specific reasons exist for departing from that standard; heavy traffic grades, too steep grades, railway special work, around watering troughs, etc. We believe that engineers have nearly all reached the conclusion that a city's paving map should not resemble a crazy-quilt, with several types of paving being laid under the same general conditions, when it can certainly, at this late date, be determined which of the several is the best for a certain condition in a certain city. In fact, I do not think it was ever the engineers that were responsible for our crazy-quilt paving maps; these are the work of the politician and his good friend, the pavement promoter.

You seem to doubt that certain pavements cannot have proved economical on certain streets "had they lasted forever without repair or renewal." If you were bankers instead of engineers, I am sure you would not disagree with me on that point. The annual interest on the original cost of some pavements, alone, is more than the interest on the original cost plus the full maintenance and renewal costs of other pavements on streets where the traffic does not justify the heavy original expenditure. If you will consult your copy of "Paving Economy," especially the chapters relating to permanency cost, the average annual cost, and elimination process table, I think you will change your opinion in this matter.

Regarding the recommendation that the so-called binder course be omitted, you are, of course, quite right in stating that all engineers would not agree on this point. I am aware that most engineers, and some of the best asphalt specialists in the country,—the others but following their lead,—do recommend the so-called binder course. My experience has been such, however, that I am compelled to take an independent stand on this point, in spite of the fact that I am well acquainted with and have personally discussed the matter with all the most noteworthy advocates of the binder course. A recent experience in Toronto, when Mr. Powell took me over a street the pavement of which he said was nine years old and consisted of a four-inch concrete foundation and a two-inch asphaltic surface, without binder course, did not shake my conviction very much, for the street is in excellent condition.

When I eliminated the so-called binder course in Milwaukee in 1910, there was much comment in the daily papers. The usual remark was that we were departing from the recognized practice, and that the new pavements would not be as good as the old ones. It was customary to refer with pride to an asphalt surface on Jefferson Street, in front of the Hotel Pfister, as an example of the old construction that was exceptionally good; it being the first asphalt surface laid in the city, and about twenty years old at the time. It occurred to me to dig up a section of this pavement, as I had certain suspicions. It had no binder course. I looked up the contract; and no binder course was mentioned therein. In fact, as I had supposed, the binder course had not reached Milwaukee in those days. The old cushion coat was provided, which is merely a laying of the regular asphalt mixture, with slight variations, in two courses. An unnecessary expense that has been abandoned.

The binder course has for some time been a bone of much contention; but, when considered in conjunction with some other paving matters that should be discussed more freely, it is relatively unimportant. A pavement well laid, either with or without the binder course, will, of course, give excellent service; and its use or elimination is largely a matter of securing the best construction and at the least ultimate cost.

C. A. MULLEN,

Director of Paving Dept., Milton-Hersey Co., Ltd.,

Montreal, May 19th, 1917.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

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BOOK REVIEWS.

The Flying Machine from an Engineering Standpoint. By F. W. Lanchester, M.Inst.C.E., M.Inst.A.E., Member of Advisory Committee for Aeronautics. Published by Constable & Co., London, 1916. 135 pages, illustrated, 5½ x 8¾ ins., cloth. Price, $1.50. (Reviewed by J. H. Parkin, Mechanical Engineering Department, University of Toronto.)

The book is a revised reprint of the 1914 "James Forrest" lecture before the Institute of Civil Engineers, which appeared in serial form in "Engineering" in May, 1914. The work forms a brief treatment of the technical aspects of flight and the aeroplane as viewed by the aeronautical engineer and constructor, and the treatment is clear and concise.

The flying machine is compared with other means of locomotion, such as the locomotive or motor car and its comparative advantages and disadvantages in this respect pointed out. The air is considered as the track on which the aeroplane travels, the various theoretical paths or phugoids being briefly examined and the serious "Catastrophic Instability" touched on. The various elements making up the coefficient of traction of the machine, including the direct and aerodynamic resistance of the aerofoil and the body resistance are then dealt with under the "Laws of Resistance." The different factors influencing these are enumerated, their relative importance shown, and the close agreement between theoretical deductions, by the author and others, and experimental data on resistance illustrated. At high speeds the total resistance is shown to be made up largely of body resistance emphasizing the importance of the stream line (ichthyoid) form. Propulsion, with a brief discussion of the propeller, is next considered, followed by a note on the power installation and the interrelation of engine and propeller.

A more extended discussion of the detailed construction of the aeroplane is then given, including brief outlines of the factors governing the design of the aerofoil, resistance of struts and wires, the effect of vertical surfaces (the wheels and propeller have a marked effect in this respect), factor of safety, and landing gear, land and marine. The work on stability is chiefly an outline of the situation as to the literature of the subject.

There follow four appendices and a reprint of a paper, "A Discussion of the Theory of Sustentation and the Expenditure of Power in Flight," which deals with the more controversial points of aerodynamics and was prepared by the author for the International Engineering Congress of 1915.

The author's high position in the mathematical and technical branches of aeronautics and his previous publications on the subject guarantee the worth of the present volume and while none of the sections have been treated in an exhaustive manner, the principal points have been indicated and their bearing on this phase of the subject. The book will not be found easy reading by those not versed in the subject of aeronautics as considerable initial acquaintance with the science is assumed and frequent references are made to the author's previous work, "Aerial Flight (2 vols., 1908, London). The book forms a concise and able summary of the state of scientific aerodynamic knowledge and the technical art of aeroplane construction at the time of the delivery of the lecture in May, 1914.

Advertising and Its Mental Laws. By Henry Foster Adams, Instructor in Psychology, University of Michigan. Published by The Macmillan Co. of Canada, Limited, Toronto. 329 pages, 23 illustrations and numerous tables, 5 x 7½ ins., cloth. Price, $1.50 net.

An interesting study of the psychology of advertising for the advertising man and for the student, containing, in addition to the theoretical material, much experimental data.

The basic principles of psychology which are related to advertising, and their application, are clearly presented. The complexity of an advertisement is reduced to its elements, to show with mathematical exactness the effect of the various elements. The results of laboratory experiments are compared with results of actual advertising campaigns, showing the strikingly close relationship between the business and the theoretical tests.

The author analyses action, showing why advertisements lack in effectiveness, and indicates devices which will improve pulling power.

This treatise is a valuable addition to advertising literature, and one of the most practical and thorough books ever published on the subject. Its study will unquestionably be of great benefit to every advertising man and to every business man who advertises.

English and Engineering. By Prof. Frank Aydelotte. Published by the McGraw-Hill Book Co., Inc., New York. 390 pages, 5 x 7½ ins., cloth. Price, $1.50 net. (Reviewed by R. O. Wynne-Roberts, Toronto.)

The perusal of this volume of essays by writers of international fame has afforded the reviewer a degree of pleasure not often enjoyed. Mr. Aydelotte is the professor of English in the Massachusetts Institute of Technology and his object in making the selections is to help students to express themselves in writing and speaking, not merely grammatically but with order, force, sincerity and such

charms as their natures will allow. And also to show that the function of English is to furnish something of the liberal, humanizing and broadening element which is more and more felt to be a necessary part of an engineering education. The engineer is destined to play an important part in the drama of national life and must therefore be prepared to undertake his share of duties and responsibilities. The engineer, then, "must speak in terms of civilization, in human terms as well as material, or be a traitor to his opportunities." The introduction to this book is worth a careful perusal, for it contains many thoughts expressed in simple yet eloquent phrases.

The book contains excellent essays on Writing and Thinking, The Engineering Profession, Aims of Engineering Profession, Pure Science and Applied, Science and Literature, Literature and Life. One of the essays was written by Mr. John Lyle Harrington, who was educated at McGill University, Montreal. He contends that language is the engineer's most important tool and it therefore behoves him to see that it is always in good order. "It is because engineers are so little accustomed to order their thoughts and language properly that they have so little part in the business and correspondence of the corporations which employ them." This is a grave statement to make, but those who listen, observe and think will regretfully acknowledge that there is considerable truth in the assertion. "A technical man is, presumably, an educated man; and if he does not speak like one, suspicion is cast upon the entire range of his learning."—"Language has large weight in classifying a man infinitely more than manners or dress."—"The preparation of reports, specifications and contracts is the most particular and momentuous task the technical man has to perform."—"Probably the majority of the civil lawsuits are caused not by trickery or deceit or dishonesty but by the use of ambiguous words and phrases, bad ordering of the matter, incompleteness and other faults in the language of the correspondence, specifications and contracts." Such are a few of the observations made by Mr. Harrington.

Dr. Mann states that nearly one-third of the answers to enquiries made by the Joint Committee on Engineering Education complain of the engineer's inability to express himself well in speech and writing.

The reviewer had previously read the late George S. Morrison's book titled "The New Epoch," and without doubt it should be read by all engineering students. Three of Morrison's essays are presented here. One of his epigrammatical observations is as follows: The engineer "is the priest of material development, of the work which enables other men to enjoy the fruit of the great sources of power in nature and of the power of mind over matter. He is the priest of the new epoch, a priest without superstitions." An essay by General Francis A. Walker, a graduate of Amherst, also should be of special interest to Canadians. He states that the student's success in life and in his professional and social position largely depends upon the manner in which his work is done in college. He argues that "all that can be asked in regard to any school is that there shall be zeal in study, delight in discovery, fidelity to the truth as it is discerned, high aims and ambitions which have not sole or primary respect to material rewards." Such a standard is a magnificent one to attain, and requires the services of men of fine qualities to maintain.

Prof. Haultain has often publicly emphasized that the most important function of an engineer is to be useful to the community and in this regard he has the endorsement of General Walker—"to become an useful man, well-equipped for life, capable of doing good work, respected and entitled to respect," should be some of the attributes of an engineer.

The other writers of the essays are such men as John Ruskin, Arnold Bennett, Frederic Harrison, George Henry Lewes, John Butler Johnson, Thomas Henry Huxley, John Tyndall, John Henry Newman, Matthew Arnold, William Wordsworth, William P. Atkinson, Robert Louis Stevenson, Ralph Waldo Emerson and Thomas Carlyle. Stevenson's essay on "The Influence of Books," is excellent; in fact, all of the essays are excellent, but some are more easily assimilated by the reader.

This volume should not only be on the engineer's shelf, but frequently read, for by repeated perusals and study we may acquire an adequate diction to clothe the skeleton thoughts we desire to express.

Instructions to Locating Engineers and Field Parties. By F. Lavis, M.Am.Soc.C.E. Published by the McGraw-Hill Book Co., Inc., New York. 44 pages, 10 folding maps and charts, 6 x 9 ins., cloth. Price, $1.00. (Reviewed by James H. Kennedy, M.Can.Soc.C.E., Vancouver, B.C.)

This work is designed to fill a long-felt want, as there has not been any work published on this subject confined exclusively to just what is necessary to this class of work, though there are several larger works that give instruction along this line, together with other matters. I thing it will become quite popular with the younger locating engineers especially. The work bears the earmarks of an author who has had experience in the field in which he writes. The instructions given for carrying on survey work are in accordance with the best up-to-date practice for large undertakings, and no doubt are intended to be varied somewhat for smaller undertakings and local conditions, that will be apparent to the man in charge.

In regard to the keeping of field notes the author gives excellent advice; and he might have gone further and advised the instrumentman that no company will keep a man on the payroll for the purpose of an expert to interpret his own notes, and no instrumentman who does not keep his note book properly indexed, dated, etc., up-to-date as the work proceeds, should be allowed on such work.

The lists of equipment, supplies, etc., are very full and complete and will be found a very great help to engineers outfitting for work. There are many engineers, who are masters of the situation when locating work is in progress, but find great difficulty in making the proper lists of supplies for camp outfit and provisions.

The work should be in the stationery box of every locating engineer when he leaves the head office, and for distribution in Canada it is to be hoped the author may add a page giving the requirements of the Railway Commission regarding preparation of plans and profiles.

Manual of Reinforced Concrete. By Marsh and Dunn. Published by Constable & Company, London, 1916. 475 pages, 101 illustrations, 4¼ x 6½ ins., leatherette. Price, $3.00. (Reviewed by Peter Gillespie, C.E., University of Toronto.)

The third edition of Marsh and Dunn's Manual of Reinforced Concrete has recently come to hand. The authors, in rewriting the volume, have introduced much new material and incidentally omitted some matter included in previous editions, in order to keep the book within reasonable limits. The work is largely a compilation from a great multitude of sources, the publications of the British and American engineering organizations and the technical press of both the old world and the new

being frequently quoted. The notation employed is the standard adopted some years ago by the Concrete Institute of London and other influential British organizations and to one accustomed to the symbols now so generally employed by writers on this side of the Atlantic, a little difficulty in reading results. One cannot but feel that the usefulness of this excellent reference book to American readers will be sensibly reduced because of the use of an unfamiliar notation.

The first 113 pages of the volume are devoted to matter descriptive of materials and of construction methods. Then follows some 300 pages which are given over to theoretical matter, the first third of which is a discussion of the mechanics of beams, slabs and columns; and the remainder of which consists of the application of these principles to the design of a multitude of structures comprising apparently nearly everything to which reinforced concrete as a structural material can lend itself. Specific computations are facilitated in actual design by a large number of inserted graphs or charts covering beams, columns and T-beams, from which the busy designer can readily obtain much of the information he desires. It is interesting to observe that in the discussion of the stability of retaining walls, the theorem of Professor Rankine is easily given the first place. Indeed, the influence of that illustrious writer whose works have held for over two generations a unique and respected place in the literature of engineering, is plainly evident in many places throughout the book. The treatment of continuous beams is much more complete than is ordinarily found in American text books. The concrete truss without diagonals is briefly considered. To the flat slab, here designated the "mushroom" floor, several pages of discussion are devoted and the computations for a four-way floor of assumed span and loading are worked out in detail after a method generally attributed to Mr. A. R. Lord. The regulations of the city of Chicago governing this now popular type of construction as adopted some two years ago, are included. The computation of reinforced concrete beam deflection receives a brief consideration. The discussion of the retaining wall seems quite complete, and includes the full computations for a wall with counterforts for assumed conditions. The reinforced concrete arch of several types is treated according to the semi-graphical method. Other sections are devoted to coal bunkers, chimneys and dams. The final chapter is given over to practical geometry, tables of areas, metrical equivalents, properties of rolled shapes, etc., of much the same character as is found in the ordinary handbook.

The volume seems to have been compiled with a proper regard to arrangement and continuity and because of the scope of the subjects included, should become a valuable addition to the designer's library.

Preliminary Mathematics. By Prof. F. E. Austin, E.E., Hanover, N.H. Published by the author. First edition, 1917. 169 pages, $4\frac{3}{4}$ x $7\frac{3}{4}$ ins., cloth. Price, $1.25. (Reviewed by Alfred S. L. Barnes, Hydro-Electric Power Commission of Ontario.)

This is a small book of some 170 pages which, like several others which have been published within the last few years on the same subject, commences in a very elementary way, so much so as to seem tedious to the ordinary reader of average education. At the same time, it gradually leads up to more advanced work in such a way that any one going through it seriously should be able to follow it up step by step without difficulty.

Arithmetic is dealt with at first, but this is soon merged into the use of letters instead of numerical values, thus introducing algebra. Numerous worked-out examples are given, together with many problems left for the reader to solve.

The use of logarithms is explained and algebraic methods of extracting square and cube roots, etc., are shown, as well as problems in both arithmetical and geometrical progression.

On page 60 in the first paragraph the printer appears to have got mixed in the use of some of the letters of the Greek alphabet, as the words "logos" and "arithmos" are incorrectly given in that language.

The book should be quite useful to students or to older persons desirous of learning a little elementary mathematics themselves, which is the object the author has in view.

Lubricating Engineer's Handbook. By John Rome Battle, B.S.M.E. Published by the J. B. Lippincott Co., Philadelphia. 333 pages, 114 figures, 6 x $9\frac{1}{4}$ ins., cloth. Price, $4.25 net. (Reviewed by C. I. Grierson, Imperial Oil Co.)

Mr. John Rome Battle has in his "Lubricating Engineer's Handbook" an admirable, useful and concise publication. This publication cannot fail to be appreciated universally.

This may well be called an age of engineering and machinery. Standardization by specification must of necessity be recognized. Mr. Battle in this handbook has explained thoroughly the principles of lubrication, both theoretically and practically, as only one who "knows" can do.

The overcoming of friction is one of the greatest problems of our national life. Friction is overcome mostly by lubrication. A working knowledge of lubrication is imperative. Engineers and those in charge of machinery are fast becoming appreciative of the selection and use of correct lubricants and the fact that oil is cheaper than machinery. The old-time saying that "oil is oil no matter what it is used for" is fast depreciating. These facts are very ably covered in Mr. Battle's handbook.

The alphabetic index, together with the chapter index, illustration index, and test of tables and charts reduces reference troubles to a minimum.

Every engineer, manufacturer, or person responsible for the supply of lubricants should not consider his library complete without this publication.

Mr. John Rome Battle is to be congratulated for this compilation of much-in-demand knowledge.

PUBLICATIONS RECEIVED.

Canadian General Electric Co., Limited.—Annual report, 1916.

Canadian Society of Civil Engineers.—List of members, Toronto branch, 1917.

Report of the Director of Forestry for the year 1916. Issued by the Department of the Interior, Canada.

Commission of Conservation, Canada.—Review of work of the Commission. By Sir Clifford Sifton, chairman.

Temiskaming and Northern Ontario Railway Commission.—Fifteenth annual report for the year ended October 31st, 1916.

Mines.—Annual report of Mines, of the Province of Nova Scotia, 1916, issued by the Department of Public Works and Mines, Halifax.

Hydro-Electric Power Commission of the Province of Ontario.—Ninth annual report for the year ended October 31st, 1916, Vol. I.

Ymir Mining Camp, British Columbia.—By Charles Wales Drysdale. Memoir 94, No. 76, Geological Series, Department of Mines, Canada.

Geology of Graham Island, British Columbia.—By J. D. Mackenzie. Memoir 88, No. 72, Geological Series, Department of Mines, Canada.

Concrete Highway Bridges, Ontario, 1917.—General specifications. Appendix to the Annual Report on Highway Improvement, Ontario, 1917.

Canadian Woods for Structural Timbers.—Bulletin No. 59, Forestry Branch, Department of the Interior, Canada. R. H. Campbell, Director of Forestry.

Chlorinators at Dunwoodie.—Reprint by Wallace & Tiernan Co., Inc., New York City, of article by T. D. L. Coffin in the "Engineering News." Seven pages and five illustrations.

Earth, Sand-Clay and Gravel Roads.—By Charles H. Moorefield, Senior Highway Engineer. Bulletin No. 463. Issued by the United States Department of Agriculture, Washington.

Conservation of Life, Public Health, Housing and Town Planning.—Forty-eight-page pamphlet, issued by the Commission of Conservation, Ottawa, dealing for the most part with Ontario problems.

The Tractive Resistance on Curves of a 28 ton Electric Car.—By Edward C. Schmidt and Harold H. Dunn. Bulletin No. 92, Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 25 cents.

Province of Nova Scotia.—Annual report of the Highways Division of the Department of Public Works and Mines and of the subsidized railways for the year ended September 30th, 1916. By Hiram Donkin, C.E., Road Commissioner and Provincial Engineer, Halifax.

Durability of Stucco and Plaster Construction.—By R. J. Wig, J. C. Pearson and W. E. Emley. Technologic papers No. 70 of the Bureau of Standards, Department of Commerce, Washington, D.C., being a progress report, containing results of investigations up to April, 1916.

International Joint Commission.—Hearing and argument in the matter of the application filed August 28th, 1916, of the International Lumber Co. for approval of the obstruction of the waters of the Rainy River at International Falls, Minn. Published by the United States Government, Washington, D.C.

Water Powers of Manitoba, Saskatchewan and Alberta.—By Leo G. Denis and J. B. Challies. Published by the Commission of Conservation, Canada. This report is the second in the series on water-powers in Canada to be published by the Commission of Conservation. The third volume, "Water Powers of British Columbia," which is now in press, will complete the Commission's general inventory of this item of the Dominion's natural wealth.

Paving Economy—Road and Street.—By Charles A. Mullen, Director of Paving Department, Milton-Hersey Co., Montreal, Que. Paper, 5½ x 8½ ins., 98 pages and cover. Industrial and Educational Press, Montreal. Price, $1. This is a treatise on the financial side of road and street work, with particular reference to standardization of pavements. The author deals with many problems that the practical highway engineer is likely to meet with in everyday practice. There is also a great deal of useful advice for those who are most directly responsible for the financing of road work, and who find themselves in need of a working knowledge of pavement values.

CATALOGUES RECEIVED.

Corr-Mesh.—Catalogue issued by the Corrugated Bar Co., of Buffalo. Includes designing tables, graphical construction details, specifications, and photos showing methods of handling and erecting the material.

Spraco Products.—Bulletin No. 501, issued by the Spray Engineering Co., 93 Federal Street, Boston, Mass. Contains 15 pages, is well illustrated, and is a condensed summarization of the principal Spraco developments.

Hayward Buckets.—Catalogue 43, issued by the Hayward Co., 50 Church Street, New York. Contains 80 pages, is well illustrated, and is a very comprehensive catalogue upon the subject of digging and rehandling buckets.

The Puzzle of Prosperity and Its Solution.—Booklet issued by the Department of Publicity of W. S. Barstow & Co., Inc., Sandusky, Ohio, containing photographs of some of the construction work accomplished by the company.

How Better Lighting Yields You More Profits.—Twenty-four-page illustrated booklet, issued by the National X-Ray Reflector Co., 21 West 46th Street, New York, describing their system of X-Ray engineered lighting.

Prentiss Vises.—Illustrated catalogue No. 50, issued by the Prentiss Vise Company, 110 Lafayette Street, New York City. Contains 72 pages, and describes fully the complete line of vises manufactured by the company, together with price list.

Regarding Ballast Plant.—A unique circular—part circular, part letter—by the Traylor Engineering & Mfg. Co., of Allentown, Pa., regarding ballast plant equipment; discussing gyratory and jaw crushers, also screening, elevating and conveying equipment.

Riveting Machines.—Forty-page catalogue of the John F. Allen Co., of New York, on portable pneumatic, compression and hammer riveting machines. Adequately illustrated and very readable, being well arranged with illustrations on left-hand pages and descriptions on facing right-hand pages.

Why?—This latest publication of the Wallace & Tiernan Co., Inc., 137 Centre Street, New York, contains a great many facts that will be found of interest to the sanitary engineer, and, in fact, to all those who are concerned as to the purity of water supply, either for industrial or municipal purposes.

The Clay Pipe Book.—Issued by the International Clay Products Bureau. Pamphlet of 42 pages, containing interesting information concerning the merits of vitrified sewer pipe. Some interesting tables are included showing the capacities of vitrified pipe, methods to be employed in laying pipe, etc. Illustrated.

Iroquois Asphalt Repair Wagons.—Bulletin No. 5 of the Barber Asphalt Paving Co.'s Iroquois Works, Buffalo, N.Y. Four pages, six illustrations. This wagon is capable of supplying material for patching from 50 to 75 sq. yds. a day. Weighs two tons. Used to remelt old asphalt or cakes of new mixture, for heating sand and stone with a.c., or as a sand or stone dryer, or as a substitute for melting kettle.

Nationalization Would Add Billion to Country's Debt*

So Says the Minority Report Presented by the Chairman of the Railway Inquiry Commission—Opposes Drayton-Acworth Recommendations—Advises Continuation of Public Aid to Canada's Railroads

By ALBERT HOLLAND SMITH
President, New York Central Lines

THE Canadian Pacific is amply able to take care of itself. It can and does provide competition with the other railroads. In order to be most serviceable to Canada, it should be continued, subject only to such equitable regulation as is accorded to all lines.

The Grand Trunk succeeded in the east and failed in the west. The Canadian Northern succeeded in the west and was jeopardized by its eastern expansion.

There is extensive duplication of lines in the west; the unsuccessful Grand Trunk Pacific lines are found among the successful Canadian Northern lines. Public policy demands the unification of these lines, for great economies could be thereby accomplished.

There is extensive duplication in the East; the new Canadian Northern lines among the older lines of the Grand Trunk proper. Great economies in proposed investment and operating expenses await the joint working of these properties.

There is wasteful duplication in the connecting region between North Bay and Winnipeg, where the Canadian Northern line parallels the government line. Economy awaits the joint working of these lines.

Remedies Recommended.

Consideration of all phases of the problem leads me to recommend the following remedies for the existing situation: Let the Canadian Pacific alone; let the Grand Trunk operate the eastern lines now held by that company and the Canadian Northern; let the Canadian Northern operate the western lines now held by that company and the Grand Trunk Pacific system; let the government operate the connections or procure their operation by private companies; all of which should be done under arrangements that are equitable, and yet look to the not distant day when the country will have survived the war and resumed its prosperous growth.

There may be several ways by which this can be brought about, but the one that has appealed to me is that which seems to be the least disturbing of values and credit and involves no untried schemes or protracted disputes. Therefore, I beg to make the following suggestions:—

1. Amend the regulating policy so that the Railway Commission may have jurisdiction over all railroads in the matter of maximum and minimum rates, the issuance of securities, the building of new railways, or the extension of lines, and other matters properly within the scope of governmental supervision.

2. Create a board of trustees, consisting of two government officials and three private citizens, to act for the government in the matters hereinafter proposed.

Relieve the Grand Trunk.

3. Relieve the Grand Trunk Railway Company of its obligation to lease the Transcontinental, and require the company to relinquish all claims upon the Transcontinental; require it to lease to the Board of Trustees the Grand Trunk Pacific railroad properties at a rental amounting to the net annual fixed charges; require it also to take under lease the Canadian Northern properties east of North Bay and Parry Sound, and pay as a rental the net fixed charges on those properties. The time of the lease should be for twenty-one years. The Grand Trunk's investments, other than railroad, in the West may be disposed of by the company as it may elect, and in accordance with its best interests.

4. Require the Canadian Northern Railway Company to confine its operation to the field west of Winnipeg. Relieve it of the line east of Winnipeg by leasing for twenty-one years to the governmental Board of Trustees at a rental of the net annual fixed charges. Require it to take a lease of, and to operate for the same period the Grand Trunk Pacific Railway, and its branch lines, paying as rental the net annual fixed charges upon those properties; except that until seven years after the end of the war they shall have the immunity that was promised the Grand Trunk Pacific for a period of seven years after construction, and that they shall not be required to assume any of the extraneous investments of the Grand Trunk System in the West.

Twenty-one Years' Lease.

5. Lease the lines between North Bay and Winnipeg (except the Canadian Pacific's) for a term of twenty-one years to either the Canadian Northern or the Grand Trunk (or, in event neither applies, to any other qualified company), requiring the lessee to furnish the necessary capital for new equipment, and to maintain and operate the lines on the best terms that can be made; terms that would give the best service needed at lowest cost to the government being regarded as best. Either the government or the lessee should build a connecting line of about thirty miles near Long Lake, Ontario, to protect the better working of the two lines.

6. The government and companies should have the option of terminating, after ten years, any of the leases upon equitable terms.

The foregoing recommendations are made with a view to obtaining for Canada a maximum of efficiency at a minimum outlay. The continuance of government aid, to some of the railroads at least, will be necessary under any plan. The plan herein proposed seeks to reduce this to the lowest possible point and to centralize it upon those parts of the existing lines which are not self-supporting, and which, in the nature of things, cannot be self-supporting for years. These connecting links, "bridges," as they have been called, exist, it seems to me, as a result of that public policy which has been discussed at some length. The government may well afford to take them over and maintain them as necessary parts of the public investment in the country's development. They are not of sufficient importance to bring about those dangers inherent in government operation of this kind on a large scale, and holding them will not endanger private enterprise. It may be necessary in working out this plan to grant some additional and temporary aid to the Canadian Northern, and it will be necessary to effect some compromise with the Grand Trunk Railway Company which will enable this company to continue. Aid should be extended upon the recommendation of the Board of Trustees, who should be charged with the duty of investigating the need of and approving the aid to be rendered by the government; they should also see that the government receives for that aid such security as will give it a reversion in case of default.

Fair Solution of Problem.

The recommendations here submitted are to be considered as a general outline of what appears to be a fair solution of the transportation problem. Enabling legislation will be required in any case, and I realize that there are many technical and legal questions which will require careful attention at expert hands. If the general plan is adopted, my thought is that the Board of Trustees which I have suggested be charged with the duty of acting for the government in all matters requiring new contracts, and shall protect the interest of the government in every way while leasing, operating, or financing the property under their care to the best advantage, due consideration being given to the rights of the other parties at interest.

If for any reason it should prove inexpedient to carry out the foregoing suggestions, and if the government should find it wise or necessary to possess itself of, and to hold any considerable part of the railway properties, I should recommend as an alternative plan the formation of a private company to

*Abstracted from minority report of Royal Commission to Enquire into Railways and Transportation in Canada.

take over other operations of those properties, either as a whole or in groups. Even where a road does not earn its fixed charges, the government could profit in the long run by making the terms of an operating lease sufficiently attractive to induce private enterprise to undertake its management. The terms of the contracts would naturally depend upon the extent of the property and the prospect of earnings, but they could be so drawn as to prove attractive to private capital and at the same time relieve the government of the expense and embarrassment of government operation. Such contracts might be based upon a profit-sharing plan on a fair basis, which would leave the company a hope of reward commensurate with its efforts, and give the public also a share in the prosperity which they must help to create.

Desperate Need of Equipment.

I should like to add one other thought. The railways of Canada are in desperate need of equipment. Whatever decision is made with reference to the railways, the transportation problem is now acute in so far as equipment is concerned. I would, therefore, recommend that the government undertake at once to provide an ample supply of freight cars and locomotives against immediate and imperative needs. These cars and engines may be had, if desired, under trust agreements. It will be a simple matter to turn these cars and engines over to the operating companies under lease or contract of purchase, which may be exercised when conditions are more nearly normal.

Concluding, I would be loath to suggest recourse to any radical changes in the domestic policy of the Dominion of Canada in this time of war and stress. Remedial measures are often more efficacious than revolutionary ones, and more equitable. I have been impressed by the seriousness of your transportation problem, and in sincerity express my belief that the problem can be successfully and satisfactorily remedied by just and mutual recognition of difficulties and full and free co-operation between the government and the railroads. Fair and broad treatment of the question will, I am convinced, bring capital and personal genius commensurate with the exigencies of the present situation, and capable of developing a happy solution. I believe that the best results hitherto have been obtained by the efficiency and economy of private initiative, energy, and capital. It is no longer assumed that the self-interest of the railroad investor and operator is antagonistic to the interest of the public; rather, we have all learned, governments and corporations alike, that the two are inseparably linked and must stand or fall together. Upon these fundamental truths I base my firm conviction that the brightest outlook for the future of your great Dominion can be assured through the extension of private railroad enterprises. The hope of honor and the reward of public approval must be open to human kind to get the best results from human endeavor.

Facing the urgency of the need, considering the part which the government has taken and the responsibility which it shares, and keenly alive to the magnitude and the importance of the tasks now placed upon the railroads and the greater tasks which they will face, I see no safe alternative but the government shall continue, with discrimination and resort to all available safeguards, and under a policy of proper regulation and co-operation of effort, to aid the necessitous railroads of the Dominion until such time, which I hope and believe will not be far distant, when these will become self-supporting and the problem will be solved.

Extensive Re-Organization Unnecessary.

We are asked to make suggestions in regard to "the reorganization of any of the said railway systems or the acquisition thereof by the State; and in the latter case, the most effective system of operation, whether in conjunction with the Intercolonial Railway or otherwise."

The first practical question is, therefore, the need of reorganization of any of these three transcontinental systems; the second is whether they should be acquired by the State; and the third is whether the status of the Intercolonial can be changed; and, if so, can the road be advantageously grouped with either of the three systems.

In such suggestions as I shall make, I am influenced by consideration of the public policy as evidenced by past governmental acts. I further assume that the existence of these roads through the direct aid and sanction of government is conclusive evidence of the fact that the people really desire them. That they were built in advance of their need for ordinary commercial uses—a fact which is emphasized by the present abnormal economic situation—does not appear to me a sufficient reason for condemning the policy of national development, or the wisdom and integrity of those who have built the roads under that policy. Neither do I think that there exists any condition to warrant taking up a new and untried public policy, which may lead to greater difficulties than those which are now faced.

The history and standing of the Canadian Pacific Railway, and its public service as a carrier to-day is sufficient assurance that it does not need reorganization. The scope of its business, extending to other lands by steamships and commercial connections, and the control of many thousand miles of railroads in the United States, would afford sufficient reasons, if none other existed, for dismissing the idea of its acquisition by the State.

So much of the Intercolonial as is serviceable to the Canadian Pacific appears to be now used by it, either as a local connection or through trackage rights. Moreover, the two have existed separately for many years as competitors, and no new reason appears why the relations of the Intercolonial and Canadian Pacific should be changed for the future, unless the people of Canada are satisfied that better results would be obtained for the territory served by the Intercolonial if it were in the hands of the Canadian Pacific.

G.T.R. Cannot Carry Obligations.

The Grand Trunk Railway Company has stated that it is beyond its power to assume and carry the obligations which would be imposed upon it if it should try to become such a transcontinental system as the plans of 1903 contemplated. The company has not attempted to bring about the organization of a system approximating that of the Canadian Pacific, or even the Canadian Northern, nor can it do so.

In view of the parent company's inability to carry out its original plans, and to discharge its obligation, the question is, what disposition is to be made of the various roads which were intended to be, but did not become, parts of one operating system?

My colleagues have recommended that the stockholders of the Grand Trunk Railway Company be paid an annuity, which is to be a "moderate but substantial portion of $3,600,000, the average dividend payment for the last ten years." This recommendation is in spite of the facts noted in the report that there are arrears in maintenance which require the expenditure of twenty-one millions of dollars, and that the company has charged to capital items which should properly have been charged against income, these facts indicating that there have been some dividends paid which have not been earned. Considering this situation, and also the obligation of the company in the West, I am not impressed with the justice of paying an annuity to the stockholders in exchange for a surrender of this property. I also would be liberal to them, but I would allow them to keep their property and give them a chance to work out their own salvation. To that end, I would recommend that a settlement be effected between the government and the Grand Trunk Railway Company. The railway cannot carry out its part of the contracts, and it should be relieved of further embarrassment. On the other hand, the stockholders of the Grand Trunk Railway should be required to curtail or forego their dividends for the present, and the entire earnings be applied to the rehabilitation of the road through a term of years. The government thus gives up a present claim which the debtor cannot pay anyway; in turn, it will enjoy improved and extended service, which may be worth far more to the welfare of the people. I should also give the government some claim upon the future earnings of the Grand Trunk, so that it may share in any future prosperity which this action makes possible.

Put Itself Into Shape.

Reorganization of the Grand Trunk is desirable only in so far as it shall be required to put itself in shape to discharge efficiently its functions as a carrier. Whether it shall retain all of the subsidiaries which it has accumulated through the past fifty years depends in large measure on what they can contribute to the main property. Careful study of each of the subsidiaries will lead to definite conclusions from the standpoint of the Grand Trunk and its future welfare.

What the Grand Trunk needs most of all is to be relieved upon equitable terms of the embarrassment that it has incurred through the failure of the transcontinental scheme. The acquisition by the State of the Grand Trunk Railway proper presents much of the embarrassment that would obtain in the effort to acquire the Canadian Pacific, for here also, in addition to the question of equity involved, there is

the problem of some two thousands miles of railroad owned in the United States; and the fact that the Grand Trunk's principal seaport is in the United States.

The investigation of the Canadian Northern by the Commission has disclosed evidence of skill in construction and efficiency in management, considering the means and equipment available. The company even now earns a large part of its fixed charges, although important parts of the system have been in operation for but a year. I think there is ample justification for confidence that the affairs of the company will improve with the return of normal conditions. I see no reason for a change of management or a reorganization, excepting as hereinafter suggested.

Relation of Intercolonial.

It may be well here to consider the relation of the Intercolonial to the other roads, and the possibility of operating it in conjunction with any of them. We have shown its relation to the Canadian Pacific. The main line of the Intercolonial is about 1,000 miles, from Montreal to Halifax. It has occupied the territory for fifty years and has become adapted to it. There are apparently no operating economies available by combining it with another system that are not available to it alone. Assuming proper regulation, there appears to be no traffic interchange that could be better assured by merger. I am informed that the Maritime Provinces consider the use of the Intercolonial as a right to which they are entitled. Moreover, the government has built the Transcontinental, a part of which was in compliance with plans of the Grand Trunk, while the rest of it is so placed that it ought to continue to be operated in conjunction with the Intercolonial. The present status of the Intercolonial and the eastern part of the Transcontinental should be continued as a government operation. The results of such operation should, however, be reported to the people of Canada in exactly the same form as is required from other railroads. And these roads should be subject to the same reasonable regulation as is exercised over all other railroads.

Mention might be made here of the railroad that the government is building from the Saskatchewan River to Hudson Bay. The object in the construction of this road has been stated to be that of obtaining a shorter haul from the western provinces to Europe. The bulk of the traffic to follow this route must necessarily be diverted from the roads extending from Winnipeg to the East, so that the project seems to be an instance of competitive construction, which cannot be justified in this case, even on the ground that it opens up new territory.

There are numerous local railway projects, within provincial limits, which at the moment seem to have little effect upon this general railroad problem. Disposition of these may well await developments as to their necessity and utility when they assume operation. There is little that can be said just now as to their probable relation to the existing means of transportation.

Natural Route to East.

The Great Lakes and the St. Lawrence River furnish a natural route from the western country to the East, and to the Atlantic ocean for a part of the year. Numerous steamship lines between Port Arthur and Georgian Bay or the lower lakes and St. Lawrence River ports afford adequate transportation under normal conditions, though somewhat affected by customs requirements and other factors. In view of the heavy movement of grain in the last three months of navigation, regulations governing shipping should be as favorable as practicable, for the hauling of grain over the long distances to the eastern seaboard by an all-rail route involves a problem in car supply and cost which renders such a haul unprofitable for rail lines.

The success of the Canadian Pacific steamship lines has led to the suggestion by some that the other railroads ought also to establish steamship lines. I do not believe that this success was primarily due to the railroad ownership of the ships. Temporarily, the war seems to have put a stop to plans for railroad-owned steamships. If, at the close of the war, it is to be tried again, it would seem advisable first to ascertain whether other ships cannot be induced to schedule sailings before railroads incur the responsibility of making additional investment in ships. There are ships running in regular postal routes with subventions. Perhaps the government might well require, in connection with its subventions, that ships give equal service to the railroads without discrimination among them, thus removing another cause for the employment of duplicate facilities.

In visiting the various ports, I was impressed with the facilities installed and being installed. At Halifax, particularly, important works were actively under way, necessitated I believe, by the overseas traffic for war purposes. It is likely that the future development of steamship terminals in connection with railroads will be difficult to fix until normal conditions resume. Meanwhile, the Atlantic seaports are so much involved in the emergencies of war as to place them beyond the scope of this inquiry. In any event, such works of harbor improvement and development as are the result of war measures will be there at the close of the war as a foundation for what the future may hold.

Unable to Join Colleagues.

I am unable to join my colleagues in their recommendations. They propose that practically all of the railways in Canada, except the Canadian Pacific and the American lines shall be turned over to a corporation to be managed by a board of trustees appointed by government. They insist that this board is to be permanent and self-perpetuating. I do not know by what means one parliament can bind its successors to a given policy, especially in so simple a matter as changing the organization of a government board. My friends seek to avoid government ownership and operation, in fact, condemn it as inadvisable, but propose a plan which contains so many elements of danger in the direction which is sought to be avoided that I am unable to join them.

Their plan would add about a billion dollars to the direct debt of Canada. The interest on this is about forty millions, adding very largely to government expenses. Judging from the experience Canada has had with its government railways, it is fair to assume that this would remain a permanent burden. Operated by private companies, this interest would ultimately be borne by the companies without recourse to the government funds, and at the same cost of service to railway patrons as would obtain under government operation.

Their plan also leaves out some of the railways. This is unfair to the investors whose property is to be subjected to government competition. It also discriminates in the method by which the respective properties are to be acquired. I cannot approve the proposed centralization of control. There are problems local to separate regions which often require prompt action and co-operation between the railroads and the people served. There is a need everywhere for that prompt and efficient service which can come only from a knowledge of local conditions and responsibility for meeting them. I cannot believe that centralization, remote responsibility and control, will ensure good service to the people of Canada.

Fundamental Defect of Plan.

The recommendation creates a Dominion Railways Company, owned by the Dominion government, to take over those roads. There are about 7,000 miles in the United States controlled by Canadian companies. The Canadian railways depend for no inconsiderable portion of their revenue on United States traffic. A fundamental defect of the plan, therefore, is in placing the government in the railroad business, not only in Canada, but also in operating railroads in the United States subject to both federal and state regulation.

Through private railway management, Canada has obtained about one mile of railroad for each $30,000 of government aid of guarantees, which is but a fraction of the cost of government railroad undertakings. In some instances, a large proportion of the aid was in land, the value of which was produced by the building of the railroad and the settlement thereby made possible. Compared with the total outlay involved in producing railroads by the government for itself, as, for instance, the case of the Intercolonial or the Transcontinental, from three to six times that amount have been used to realize equal results. This shows distinctly the value of enlisting and retaining private enterprise.

ONTARIO SUES ELECTRICAL DEVELOPMENT CO.

Attorney-General Lucas, of the province of Ontario, has issued a writ on behalf of the Commissioners of the Queen Victoria Park, against the Electrical Development Co., claiming $225,665 under an agreement, dated January, 1903, between the Park Commission and Sir Wm. Mackenzie, Sir Henry Pellatt and the Hon. Col. Frederic Nicholls. Damages are for the value of power said to be developed by the defendants in excess of the amount which they were licensed to develop. Also an injunction is applied for to prevent the company from making any further excess development.

DIVERSITY OF PATENT LAWS

Patent law in the British Empire is discussed in the recent report made by the Dominions Royal Commission. In the United Kingdom anyone who imports an invention from abroad, provided that it is not in use in the United Kingdom, may obtain a patent, but any hardship that might arise from this provision is modified by the adherence of the United Kingdom to the International Convention for the protection of industrial property, under which an inventor in any country adhering to that convention is allowed priority over other applicants during a period of one year from the date of his foreign patent. Australia and New Zealand expressly refuse protection to imported inventions. The United Kingdom and most of the dominions admit to protection the assignee or legal representative of an inventor, but in Newfoundland only the assignee is given protection, and then subject to conditions.

The report says:—"There is divergence as to opposition to the grant of patents. Newfoundland provides no machinery for this. Canada allows opposition only in case of conflicting applications. In the United Kingdom, Australia, and the Union of South Africa, there are many and different grounds, and in New Zealand there are no limitations to the grounds of opposition.

Life of Patent.

"In Canada the life of a patent is 18 years, in the United Kingdom and all the other Dominions 14 years. The provisions for, and periods of, renewal differ widely.

"In the United Kingdom a patent may be revoked after four years for non-working. This provision was complained of in evidence before us in London, and the complaints were supported both in New Zealand and Australia. In Canada and Newfoundland a patent is void after two years if not worked, whilst Canada has also a provision under which a patent is voided if the patented article is imported into the Dominion by the patentee after the expiration of one year (subject to extension) from the date of its grant. In Australia and New Zealand, if working is not satisfactory, the court may by order allow a patent to be worked by others than the patentee but without revocation. In the Union of South Africa revocation in consequence of non-working is allowed after three years.

"The United Kingdom, Canada, Australia, New Zealand, and the Union of South Africa make provision for the grant of compulsory licenses by the patentee if the competent government authority is not satisfied with his working; Newfoundland makes no such provision.

As to Fees.

"Witnesses in the United Kingdom dwelt strongly on the question of fees and the heavy cost of full protection. This cost was set down in 1912 at £289 for the United Kingdom and all the Dominions, but has since been reduced to £166 by recent legislation in the Union of South Africa. Even so, the case is not so bad as these figures would make it appear, because the total sum is only payable when an inventor wishes to protect his invention throughout the self-governing parts of the Empire for the full life of the patent. What an inventor needs most is protection from the dangers of early publicity, and he can obtain provisional protection in the United Kingdom and all the Dominions for a much lower sum.

"The laws of Australia and New Zealand already resemble those of the mother country in essentials with regard both to provisional and complete specifications whilst the recent legislation of the Union of South Africa is also similar to that of the United Kingdom. Canada does not appear to contemplate provisional specifications, but allows the intending applicant for a patent who has not perfected his invention to file a description of his invention so far as it has proceeded and this filed document (called a 'caveat') gives him protection for one year. Newfoundland does not provide for provisional specification or caveat, but gives protection for six months from the date of delivery of specification.

"In view of the divergences between existing legislation, some of which, but by no means all, we have sketched above, and of the number of legislative authorities amongst whom agreement would need to be sought, immediate uniformity seems impossible. It has been suggested to us by witnesses that, if an invention has been patented in any of the self-governing parts of the Empire, it should be patentable in all parts on payment of search fees, but the fees payable for full protection are now so low that there would be no practical gain in the adoption of this suggestion.

"In the United Kingdom the renewal fees are heavy, but, as was pointed out to us in evidence, it is only reasonable that a patentee should pay more heavily for the continued right to exploit a market of 45 million persons than for that of exploiting the smaller markets of the Dominions.

"We do not think that the question of fees is one in which reform is most urgently required. There are others on which action is more needed, and also immediately practicable. These we may classify as follows:—(1) The legislation now in force in Newfoundland is somewhat out of date and could be remodelled with advantage. We hope that the necessary steps may be taken. (2) Efforts should be made to arrive at uniformity in the United Kingdom and all the Dominions with regard to compulsory licenses and revocation for non-working.

"In our judgment the Australian and New Zealand system, which we have described above, is the most satisfactory. This system should be combined with clauses for compulsory licenses.

Uniformity Without New Legislation.

"(3) Even without new legislation it should be possible to secure complete uniformity in the mother country and the self-governing dominions in regard to:—(a) the forms that have to be filled in when a patent is applied for; (b) the declaration to be appended to those forms; (c) the specifications and drawings required; (d) the amount of protection obtained by acceptance of provisional specifications. Much useless expense and trouble would be saved by uniformity in these respects. (4) Legislation is desirable to secure uniform duration of patents."

STEEL NOT AVAILABLE FOR SHIPS

Canada will not be in a position to build steel ships for at least two or three years. This was a statement of Mr. Mark Workman, president of the Dominion Steel Corporation, at Montreal. He added that scarcity of steel was the chief cause.

The entire output of steel from the Dominion Steel Corporation's plant had been contracted for by the Munitions Board up to the middle of 1918, and the chances were that this contract would run into 1919.

Some criticism has been directed at the officials of the corporation because of the sale of a ship plate mill some months ago to United States interests. Mr. Workman, when asked regarding this, explained that the plant sold was incomplete, and that it would be impossible to make ship plates from it.

No Raw Material.

He pointed out that he thought it had been purchased some seventeen years ago, had never been operated nor installed. He added that a plant properly equipped to manufacture ship plates would require an expenditure of something like $2,500,000, and the plant sold had been purchased for $70,000.

Going further into the prospects of steel shipbuilding here, Mr. Workman said that it would be an absolute impossibility for the Steel Corporation to operate a plate mill at the present time, even if they had one on the ground, because of their inability to secure raw materials. The corporation has a rail mill lying idle because sufficient ore cannot be obtained to operate it.

Extensions Cost $5,000,000.

"The Canadian Government Railways, the Canadian Pacific and the Grand Trunk are all crying bitterly for rails, but we can do nothing to help them as shell requirements just about exhaust our product," he said.

To increase the steel output they would have to start at the ore output from the mines. Additional furnaces would have to be installed, as well as new coke ovens. Work is at present well advanced on these extensions, and the corporation is spending this year something like $5,000,000 in extensions and improvements at Sydney, but this increased output is all provided for in contracts already made with the Munitions Board.

"These extensions will require a great deal of additional labor and it will be another question whether we can secure this or not," he concluded.

Shipyards are Busy.

Sir George Foster in a statement in parliament last week said:—

"Every shipyard in the Dominion of Canada which is able to build ships and is equipped therefor has not only the opportunity but has the actual contracts for building every

ship and every vessel they can turn out, and to-day the building of vessels in this country for the specific purpose of warding off and fighting the submarine peril is being carried on in all the shipyards. And in regard to the building of wooden ships an arrangement has been completed and is being carried out whereby anybody or any company that can undertake to build wooden ships and complete them within a certain time will get an opportunity to do so and will be assured that over and above the cost of building the ships they will have a reasonable profit guaranteed to them."

EDMONTON'S PUBLIC UTILITIES.

A. G. Harrison, city commissioner of Edmonton, Alta., forwards to *The Canadian Engineer* a statement of the results of operation of the public utilities of the city of Edmonton for the year 1916. This statement shows a surplus over all charges, including depreciation, of $64,788 on electric lighting and power, $24,410 on waterworks, $9,570 on telephones, and $39,430 on power-house (up to June 30th, 1916), making a total surplus of $138,198. This is reduced however, to a surplus of $18,601 on account of the deficit of the street railway, which amounted to $119,597. Mr. Harrison calls attention to the fact that a sinking fund has been maintained to retire the debentures. The street railway is earning 4½ per cent. on the capital invested, and shows a betterment of more than $16,000 over the year 1915.

ROAD AID IN SASKATCHEWAN.

H. S. Carpenter, deputy minister of highways of the province of Saskatchewan, has informed the secretary-treasurers of all rural municipalities in his province of the passing by the legislature of an Act which grants not less than $300 and not more than $600 per annum to each rural municipality for the purpose of assisting in the maintenance and improvement of main roads leading to market towns. The total of such grants paid in any year is not to exceed 80 per cent. of the net revenue received during the previous fiscal year from the fees for automobile licenses. Annual report is to be made to the department as to how the money has been spent.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The twentieth annual meeting of the American Society for Testing Materials will be held June 26th-29th at Atlantic City, N.J. There are to be eight technical sessions, one to be devoted to each of the following eight subjects: (1) Tests and testing, (2) Steel and iron, (3) Non-ferrous metals, (4) Preservative coatings and miscellaneous materials, (5) Cement and concrete, (6) Concrete and lime, (7) Ceramics, (8) Miscellaneous materials. A session will also be devoted to the annual address of the president, and there will also be an organization session, at which reports of committees will be received, election of officers announced, and miscellaneous business conducted.

CREDIT DUE INTERNATIONAL NICKEL.

"Credit should be given where due," says the May Bulletin of the Canadian Mining Institute, "and credit certainly attaches to the International Nickel Corporation for the exercise of a very commendable restraint in maintaining, until within a few weeks ago, the price of nickel at the pre-war figure, notwithstanding that the increased cost of production would have quite warranted an advance in the price of the metal, and that at a time when the demand was abnormally great. Had the corporation taken advantage of the opportunity that offered, it might have increased its profits enormously at the expense, mainly, of Britain and her Allies. Had the International Nickel Corporation happened to be a Canadian concern its policy in this respect would have been acclaimed as a most praiseworthy example of practical patriotism. At any rate, the course it has pursued is in very striking contrast to the greed displayed by some Canadian war profiteers."

AMERICAN PAPERS ON RAILWAY REPORT.

Some of the American engineering papers have expressed editorial views upon the reports submitted by the Canadian Railway Commission. The "Railway Age Gazette" holds the opinion that the Drayton-Acworth plan "would not serve the double purpose for which apparently it is put forward—that of avoiding the dangers incident to government management in a democratic country, and at the same time secure the advantages that are usually conferred by private management."

"While the Drayton-Acworth plan has much merit," continues that journal, "there is great force in some of the criticisms which Mr. Smith makes upon it. Is it not a fact, as he suggests, that a board of trustees created by one parliament may be abolished by a later parliament? A point of hardly less importance is as to how the proposed plan would assure efficiency in management. The first board of trustees would be chosen by parliament. What assurance is there that parliament would select competent men? If the first team were not composed of competent men, those later elected to the board very probably would not be strong men, and who is to call the trustees to account if they do not do their work well?"

"Whichever recommendation may be the more sound," says the Engineering News-Record, "the point to be noted is that both are radical. Desperate cases require desperate methods—especially in war time. The dilemma of our northern neighbor is not without its warning to us. The day is long past when we will make wholesale donations to our railroads, nor are we likely to permit wild cat construction. It is not so certain that other circumstances, controllable or otherwise, may not bring some or all of our roads into equally serious difficulties. Railroads and the public are inseparably linked—at least, in bad fortune."

CAN. SOC. C.E. ELECTIONS AND TRANSFERS.

At a meeting of the council of the Canadian Society of Civil Engineers, held May 15th, the following elections and transfers took place:—

Member—Arthur C. Tagge, Westmount.

Associate Members—Frederick R. Adelhelm, Montreal; William A. Begg, Regina, Sask.; Patrick Burke-Gaffney, Winnipeg; Frank H. Farmer, Winnipeg; William P. Gross, New Westminster, B.C.; Harold G. Phillips, Regina; William C. Rowse, Winnipeg; and John Stewart, Cincinnati, Ohio.

Students—C. W. Boast, Montreal; F. D. Pringle, Hamilton.

Transferred from Associate Member to Member—Paul F. Mercier, Montreal; Thomas S. Scott, Kingston, Ont.

From Junior to Associate Member—Henry C. Craig, St. Catharines, Ont.; William E. Janney, Toronto; Frank S. Milligan, Toronto; Stanley D. Parker, Ottawa.

From Student to Junior—Robert C. McLachlan, Port Nelson, Man.

B.C. GOVERNMENT SUES P.G.E. RAILWAY.

Action against the Pacific Great Eastern Railway Company, the firm of Messrs. Foley, Welch and Stewart, the directors of the railway companies and subsidiary concerns and against the contractor, Mr. P. Welch, has been commenced by the British Columbia government.

As against Messrs. Foley, Welch and Stewart the province seeks judgment to compel them to carry out their personal covenant to build the railway line and telegraph line, repayment to the province of moneys paid by the province on account of the railway company, etc.

Against Messrs. Foley, Welch and Stewart, and also Messrs. Tate, White and Wilson is asked an order cancelling the $24,960,000 share capital of the Pacific Great Eastern Railway Company, and a declaration that each of the defendants were directly interested in contracts, and, therefore, disqualified to sit as directors.

The province also seeks a judgment that $12,500,000 of the share capital of the railway company is the property of the Crown in right of the province as security under the Loan Act, 1916.

Editorials

HEAVY EQUIPMENT EXPENDITURES.

One of the points upon which the majority and minority reports of the Railway Inquiry Commission agree is the immediate need of railroad equipment. Mr. A. H. Smith describes this need as "desperate" and says whatever decision is made with reference to the railways, the transportation problem is now acute in so far as equipment is concerned. He recommends that the government undertake at once to provide an ample supply of freight cars and locomotives against immediate and imperative needs. Sir Henry Drayton and Mr. Acworth say that to catch up arrears of maintenance in the case of the Grand Trunk property, $21,000,000 "must be spent immediately," and to prevent arrears again accumulating future maintenance charges must be much heavier than in the past—not less than $2,500,000 more annually, according to President Chamberlin's judgment, on equipment alone. New capital expenditure of over $30,000,000 is also immediately required. The Drayton-Acworth report states also that the Grand Trunk system immediately requires at least 200 more locomotives and 10,000 freight cars.

Among the deferred expenditures of the Grand Trunk Railway system are the following items: Rebuilding and reinforcing freight car equipment, $8,943,000; equipping freight and passenger cars and engines with safety appliances, $475,000; deferred renewals in maintenance of way department, $11,761,000. The cash expenditure on the single item of rails "required to restore normal conditions" on the Grand Trunk is reported as $5,312,000. It is, of course, to be borne in mind that a portion of these expenditures are fairly chargeable to capital account, as outlined by Mr. Chamberlin in his public statement which was reviewed last week in this column.

The Canadian Northern Railway must spend $84,000,000 on a five-year programme to put the road on a paying basis, according to a special report made on their behalf. The Drayton-Acworth report says that $40,000,000 for equipment and $30,000,000 for betterments would be a moderate estimate of the Canadian Northern System's need in the next five years, assuming that that road remains separate and independent.

According to a statement made by Senator Curry, president of the Canadian Car and Foundry Company, the Canadian railroads require about 40,000 cars to bring their equipment up to present requirements. Whatever is done to solve our railroad problem, very large expenditures are necessary for new equipment to give anything like an adequate freight service and at the same time maintain normal passenger service.

WATER FILTRATION IN CANADA.

A table purporting to show the number of filtration plants in the United States and Canada has been published by a number of American engineering and municipal papers, compiled from figures supplied by Burns & McDonnell, consulting engineers, of Kansas City, Mo. According to these tables, Canada is credited with 28 plants in the year 1916, whereas the Commission of Conservation of Canada, in its report on waterworks and sewerage systems, mentions 72 municipal filter plants in Canada in 1916. The provinces of Nova Scotia, Ontario and British Columbia are omitted entirely from the aforementioned table, while the figures for Alberta, Manitoba, Saskatchewan and Quebec are incorrect.

DIFFERENTIAL OCEAN FREIGHTS

Before the war, British steamship companies made a practice of charging a lower rate to New Zealand from Hamburg and other German ports than from London, on the same classes of goods. This facilitated the competition of German manufactures with British in New Zealand. It unduly handicapped British manufacturers and destroyed, at least to the extent of the difference in freight, the advantage intended by New Zealand to be given by means of preference to the British manufacturer. No assurance has been given that similar practices will not continue after the war. The case is much the same with regard to the differential freight rates charged, for example, on asbestos from Canada to foreign and British ports.

This matter of freight discrimination receives considerable attention in the reports of the Dominions Royal Commission, which heard many complaints of the kind during its tour of the British Empire. The commissioners, representing the United Kingdom, Canada, New Zealand, South Africa and Newfoundland, regard "as intolerable that British ship owners should be in a position to initiate or countenance practices of a kind so directly inimical to British trade." The commissioners state that the Imperial government has not yet been convinced of the necessity or, if convinced, has not yet found the time to take the matter in hand, in spite of the representations made by more than one Dominion government. "Our investigations," they say, "have satisfied us that in normal times the combination of shipowners is strong enough to limit the freedom of shippers, whose varied and detached interests make it difficult, if not impossible, for them to combine in any effective opposition, and that therefore, in principle, it is not desirable that the operations of the steamship companies should remain longer without some measure of government supervision."

To overcome these objections, the Commissioners recommend that the contractors for subsidized mail services should be required to submit a schedule of freight rates, both of import and export, for the approval of the governments concerned, the rates when approved, not to be altered without consent. Similar action is recommended in the case of vessels, to the construction or operation of which government contributions are made. It is also suggested that the Imperial and Dominion governments should establish inquiry boards to investigate complaints of shippers. The Commissioners express themselves strongly as to the differential freight rates, and propose that the suggested inquiry boards should have authority, at their discretion, to order the abolition of differential rates which were found inimical to Imperial trade.

PERSONALS.

ARTHUR A. COLE, president of the Canadian Mining Institute, is on a trip to the Pacific Coast for the purpose of aiding the Research Council in organizing the collection of industrial information. Mr. Cole is field organizer for the central joint committees that are assisting the Council.

Dr. HOWE, of the University of Toronto, with two technical assistants, will commence for the Commission of Conservation and in co-operation with the Laurentide Company, Limited, a survey of the cut-over pulpwood lands.

S. S. SCOVIL, B.Sc., formerly assistant chief engineer of the Manitoba Hydrometric Survey, and for the last two years engineer for the Dominion Technical Board in connection with the International Joint Commission, has been granted leave of absence to go overseas with the Pioneer Construction Battalion.

K. H. SMITH, engineer of the Nova Scotia Water Power Commission, is representing the commission in tests of some specially constructed turbines, manufactured in Pennsylvania.

WILLIAM YOUNG, chief comptroller of water rights of British Columbia, has been in Montreal and Ottawa conferring with the engineers of the Industrial Research Council.

MONTREAL AQUEDUCT ENLARGEMENT.

(Continued from page 456.)

clay or rock powder. When comparatively dry or well drained, it will stand in a bank with practically vertical face, but when fully saturated with water, tends to flow in a horizontal surface and is easily eroded and transported by running water. This latter property has a very direct bearing on the safety of the conduit, in view of the proximity of the aqueduct excavation.

The ratepaying engineers in a memorandum submitted to this board, under date of March 5th, 1917, referring to the canal section of the aqueduct, say:—

"Maximum permissible mean velocity, with material as found in earth section, shall not exceed 2.5 feet per second."

In a report made during 1894, Messrs. Keefer and Vanier, speaking of the tailrace, say:—

"The surface inclination of the water when delivering its full economical discharge with a velocity of 100 feet per minute, or a little over one mile per hour, will not be more than one-half that of the present aqueduct."

This is equivalent to a velocity of 1.65 feet per second (probably surface velocity) and would indicate that the surface velocity in the old aqueduct was as high as 3.33 feet per second (2.27 miles per hour), equivalent to a mean velocity of about 2.7 feet per second (1.84 miles per hour).

On the other hand, Mr. T. C. Keefer, in a report to the city of Montreal, dated December, 1886, gives the result of a few measurements of surface velocities made in August, 1884, which gives an average surface velocity of 1.70 feet per second (1.25 miles per hour), equivalent to a mean velocity of about 1.3 feet per second (0.89 miles per hour).

No accurate information is available as to whether erosion occurred at any time in the old aqueduct canal.

From specifications for contract No. 2 it would appear that it was anticipated that exceedingly soft material was likely to be encountered in some sections of the work, as paragraph 46 reads as follows:—

"In any case where, in the opinion of the engineer, exceedingly bad plastic or aqueous material is encountered in the bottom excavations of the canal, particularly between stations 45 and 90, and whenever this material (soft clay pockets, quick sand, loam, leaf mold or muck, etc.) is so soft or silty as to be improper to insure the required bearing power of the soil, the contractor shall be required to furnish and drive wooden piles to carry the footings * * * ."

Some of the best authorities on hydraulics give figures for the allowable velocities of water in earth canals, for different materials, which vary between the values given in the table at the foot of this page.

No paving is shown on the plans for the tailrace proper, where high velocities are bound to develop on account of its small section and steep grade. Chief Engineer Mercier, in his report of the 16th December, 1916, recognizes fully the necessity of lining with concrete that section of the aqueduct, and states that it is the intention to provide for same. We fully endorse Mr. Mercier's decision in this regard.

In view of the description of the material given by the Board of Investigation for the conduit, and other information as mentioned above, and after having inspected the works, we have concluded that for the first scheme to be considered, that of the work as per present plans, we could not assume a higher permissible mean velocity for the earth sections of the headrace than 1.5 feet per second.

In our studies, under the heading of Scheme 1, we assume that the bottom is safe for a mean velocity of 1.5 feet per second (1.02 miles per hour), but we cannot, however, accept or recommend this, or any other velocity, until thorough tests have been made to ascertain what velocity it will be safe to assume in order to guard against scouring of the bed and against the undermining of the side-retaining walls.—*(Concluded in the next issue.)*

Table Showing Figures Taken as Authoritative for Velocities in Earth Canals.

	Safe bottom velocity in feet per second.	Safe bottom velocity in miles per hour.	Mean velocity in feet per second.	Mean velocity in miles per hr.
Soft earth	0.25 to 0.50	0.17 to 0.34	0.33 to 0.65	0.23 to 0.44
Clay	0.26 to 0.50	0.18 to 0.34	0.33 to 0.65	0.23 to 0.44
Sand	0.4 to 1.00	0.27 to 0.68	0.6 to 1.3	0.41 to 0.89
Gravel	2.0 to 2.6	1.36 to 1.77	2.62 to 3.0	1.78 to 2.05
Broken stone	3.3 to 4.3	2.25 to 2.93	4.0 to 5.5	2.73 to 3.75

(The concluding portion of this report, outlining schemes 1, 2, 3, 4 and 5, will be published in the next issue of The Canadian Engineer.)

The Canadian Engineer

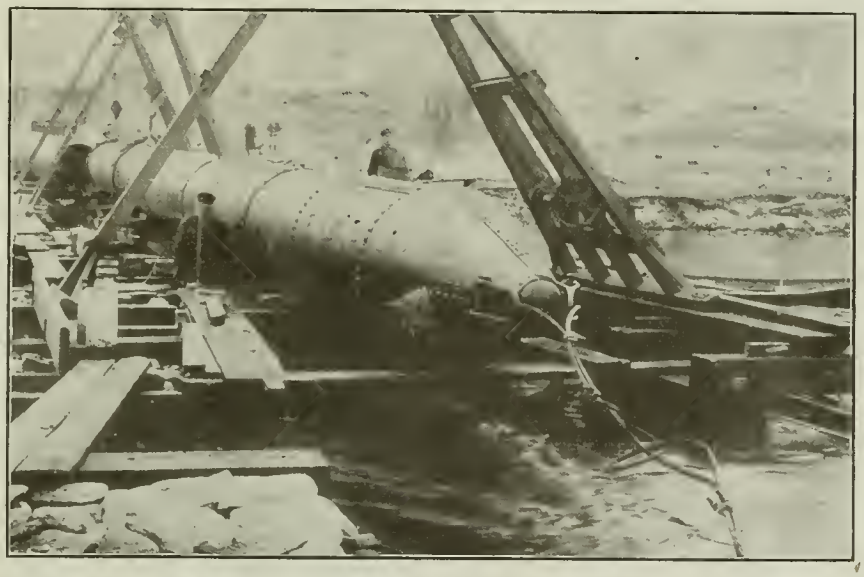
A weekly paper for Canadian civil engineers and contractors

Troubles in Constructing a 48-inch Submerged Main

Cost Details of Shafts and Tunnels—Steel Riveted Pipe Sections each 30 feet long—Description of Plant Used for Pulling Sections Into Place—Paper Read Before American Waterworks Convention Last Month at Richmond, Va.

By F. W. CAPPELIN,
City Engineer, Minneapolis, Minn.

THE distribution system required the crossing of the Mississippi River, just below the Falls of St. Anthony, with a 48-inch riveted steel pipe, ½-inch thick. The river at this point passes through a gorge some 900 feet between bluffs, which on the east side of the river reaches a height of about 100 feet above low water, and on the west side, 72 feet. On the east side there is 39 feet of sand and gravel to the Trenton lime rock; on the west side, about 11 feet from top of ground to lime rock, which is of same elevation on both sides of the river. This rock is 25 feet thick; separated from the underlaying St. Peter sandstone by 3 feet of shale. The St. Peter sand rock is some 800 feet thick. The river has cut through the rock, and the river bottom is filled with broken debris of lime rock and boulders at the deepest point (about 40 feet), then the sand rock.



Showing Torpedo Head Just About to be Launched.

Eight-foot shafts were sunk on both sides of the river, and 8-foot by 7-foot tunnels extended from the shaft to the edges of the bluffs—340 feet long on the east side and 60 feet long on the west side—and trenches dug on shores as far as possible. This work was started January 3rd, 1916, and completed May 27th, 1916. As the current is very swift at all stages of water, it would be necessary to do the river work proper in extreme low water, which occurs from the end of December to the middle of March; mostly in below-zero weather. The problem was, how to excavate the trench in the material mentioned. Pile driving was impossible; water being too swift and shallow for a dredge (and no dredge to be had on the river here). It was then decided to build cribs 4 feet wide and 8 feet long, made of 10-inch by 12-inch timbers, with partly planked bottoms; each to be loaded with about two tons of rock. These cribs to be placed about 14 feet centres across the river, and 16 feet on centres up and down the stream. On these cribs across the river, 24-inch I-beams 28 feet long would be placed flatwise to form a running track for the excavator which consisted of an American stiff-leg derrick, with which we expected to handle one-half yard Howard orange peel. Before building the cribs we did some excavating with this rig on the low shore in land on the west side, and it looked as if we could handle the material that way all right, so we started the placing of the cribs with the derrick and run across the river in a short time, completing the runway from shore to shore.

The underframe of the derrick was fitted with grooved wheels which travelled on 40-lb. rails laid loose on the I-beams. The derrick was then sent back to the west end, and excavating operations continued with the orange peel, but as soon as we got into the river we found that the orange peel would not work satisfactorily at all and we changed the rig for excavating by attaching to the boom of the derrick a dipper stick placed about 20 feet from the end of the boom with a ¾-yard steam shovel dipper; the whole apparatus working in a crawfish fashion. The excavation with this machine commenced February 18th, 1916, and the ditch was finished March 17th, 1916. It was a very hard job. The material was exceedingly bad to handle; big pieces of ledge from earlier erosions were often encountered, and they had to be simply dragged out. Some 2,500 yards of this material was excavated and dumped on the down-stream side. All small material was immediately washed away by the current, leaving the heavier stuff in place. As we excavated towards the east side the cribs were removed. As we went along, I-beams were placed on the spoil bank, which were used as a track to carry the cribs, timbers and I-beams back to the west shore. These beams also formed the pathway between the excavator and the west side.

On March 21st, 1916, riveting of the 48-inch pipe was commenced. The sections were all 30 feet long, and on March 26th, 1916, pulling of the pipe towards the east shore was commenced. The first section pulled was 120 feet long. To the end was riveted a torpedo-shaped head 6 feet 7 inches long, with heavy lugs, to which the 1⅛-inch plow-steel iron-centre pulling cable was attached. There were also two lugs on the inside of the torpedo to which a 1⅛-inch plow-steel cable was attached. The

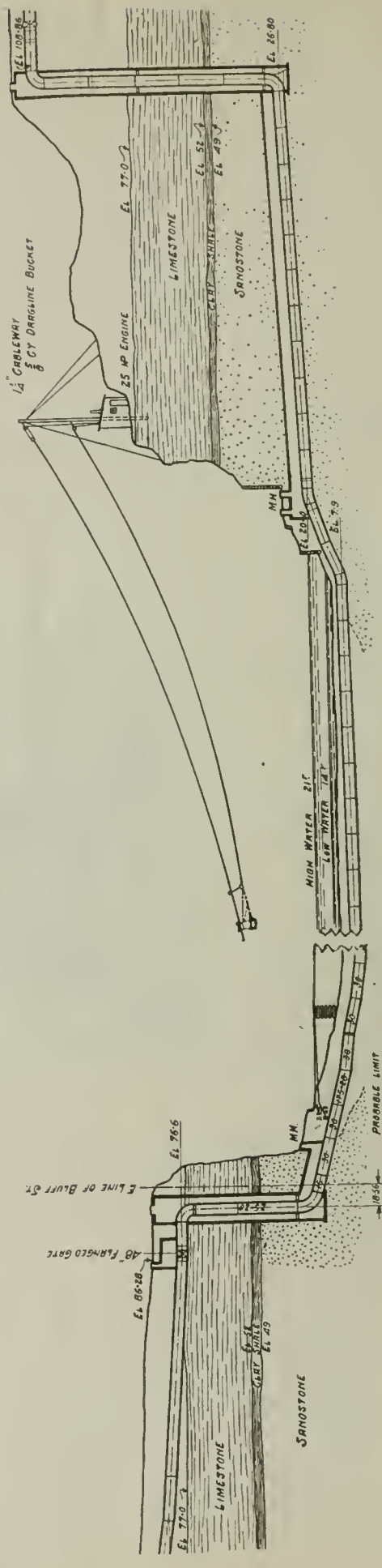
First Section Ready for Pulling.

pulling was done with a 25-h.p. Mundy engine, 125 pounds steam, and two triple sets of blocks. After this first section was pulled, 30-foot sections were added and pulled, and on March 30th, 486 feet of pipe had been pulled, and another day would have landed us on the east shore. This very day the ice broke in the upper river, about two weeks ahead of ordinary conditions, and a big ice gorge which had formed about 15 miles above the falls, broke and a tremendous flood of water came down; in fact, about 54,000 cubic feet per second, which is very nearly the maximum flood recorded on the upper Mississippi since 1800, when 60,000 to 65,000 cubic feet came down. We have a low-water record in December, 1910, for one day with 668 cubic feet per second. The flood simply picked up the pipe and laid it down stream on the flat west shore, only shearing part of the rivets in one joint about midways. The inside cable which was always anchored on the west shore saved the pipe. A few days afterwards, ten million feet of logs broke away at Anoka, 18 miles from Minneapolis, and came down over the falls and cleaned out the spoilbank, I-beams and all. The beams were picked up later.

Nothing further could be done until the river went down again. In July, the pipe was taken from where the flood had left it. It was straightened, joints repaired, and tested, and placed in position for handling again under low-water conditions. Meanwhile, the work of building shafts and tunnels went on, and was, as before stated, completed with lining May 27th, 1916. The shafts were lined with concrete, and the tunnels with 6-inch vitrified tiling.

The ditch was completely filled, of course, after the flood, with light material—sand and gravel, and smaller boulders—and it was decided that the surest and best way to excavate again would be with a drag-line excavating outfit, as follows: The track cable was started from a 14-in. x 14-in. x 48-ft. mast set up on the east shaft; elevation cable hitch about 116; the west end of cable being fastened to a bridle cable subject to pull up or down stream, with a set of ¾-inch double blocks at an elevation of about 31. Total span about 980 feet. The track cable was 1¼-inch plow-steel; the load line was ⅝-inch plow-steel, and the tension line was ¾-inch plow-steel. The engine was a Mundy 8¼ inches x 10 inches (25 h.p.) steam pressure 125 pounds. The bucket was a Sauerman ½-yard. A 20-h.p. engine was placed on the west side. We began setting up cable and engine on September 11th, 1916, and finished September 21st; and began drag-line excavation on the river proper October 16th, 1916, and finished January 20th, 1917.

The material was about as expected, but in the bottom of the trench we ran across large pieces of ledge that probably has been shifted into place during the early stages of the flood, and it became necessary to break these large debris by dynamite before the drag could handle them.

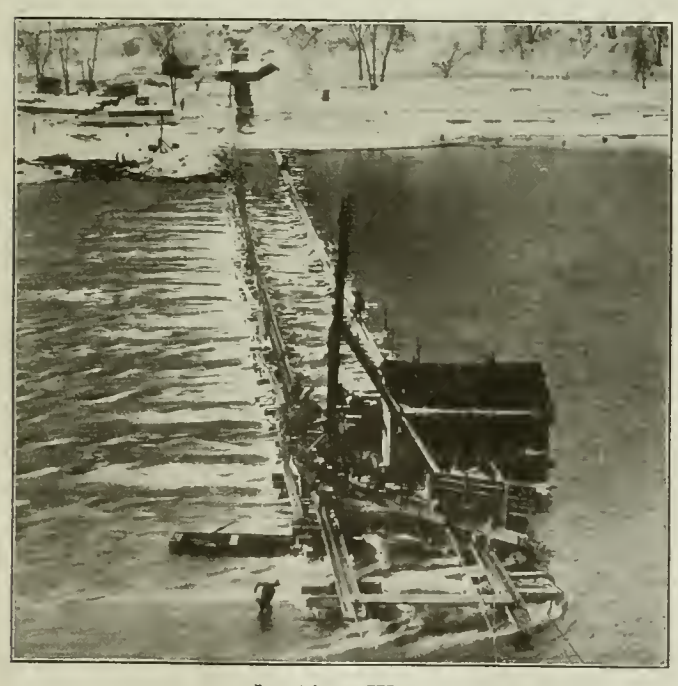


Profile Showing Elevations, Cableway Arrangement.

The drag-line bucket was dumped on staging placed right over the east side trench, and the material was slid down on the spoil bank made on the shore just below the pipe line.

On January 22nd, 1917, we began pulling the river sections of the pipe as before, and completed pulling on January 31st. The last pull was about 15 feet of a total length of pipe of 698 feet. As the pipe was pulled and sections added, water was let into the pipe on the west end, so as to keep it just about afloat above the bottom of the trench. The pipe was gradually lowered into place from the west end, and closed in and riveted up by February 9th, 1917. On the east end a coffer-dam had to be built over the pipe so as to cut off the torpedo head and put in the remaining pipe and make connections with the end of pipe at the mouth of the east tunnel. We had a lot of trouble unwatering the coffer, as we struck sand rock inside of the dam, and no puddle clay could be had—with extreme cold weather—20 below zero right along. However, the east end work was closed in on March 10th, 1917.

As soon as the pipe had been properly placed, we started to anchor same by placing very coarse fabricked bags filled with sand and cement, 1:4, around the pipe; *i.e.*, filling the entire trench in spots. Ten such anchors were placed, containing 18,000 sacks. The sand and cement was delivered on top of west bluff. The sand was heated and mixed with the cement (dry) in a small mixer and the sacks filled, then slid down a plank chute, wheeled to the river edge, then loaded on the drag-line bucket which we fitted with a small platform large enough to hold 12 bags. The east side engine would pull the bucket out over the pipe in the river and the west side engine pulled it back. As soon as the sacks had been thrown in place,



Looking West.

holes were punched in them by sharp-pointed rods to facilitate the wetting of the contents. The cement set up all right. This particular part of the work was finished March 3rd, 1917.

On March 21st, 1917, the entire work on the east side was finished, with coffer-dam removed, and with everything ready, the expected flood came, which took place April 4th, 1917. The ice gorge broke above Coon Rapids dam, about 14 miles above the falls, smashing some of the gates in the dam, and came very violently, but without doing us any harm, and we were lucky in getting through just in the nick of time. We still have high water, and it is impossible to tell if the ditch is completely filled or not. As soon as the river run secedes, we will

Unwatered Coffer-dam, Showing Torpedo Head.

empty the pipe and examine same for leaks before we turn on the city supply.

Detail Cost of Shafts and Tunnels.

Shafts.

Total vertical feet in east and west shafts, 149.7.

Material.	Amount.	Cost per vertical ft.
Coal for hoist	$ 150.00	$ 1.00
Crushed rock for concrete	237.75	1.58
Dynamite and caps	75.00	.50
Tools, etc.	125.00	.83
Cement for lining shafts	1,000.00	6.67
Use of hoisting machinery	171.45	1.15
Repairs and parts	50.00	.33
Lumber	200.00	1.34
Drilling 6-inch hole through rock for drainage	66.15	.44
Miscellaneous material	40.00	.27
Total	$2,115.35	$14.13
Labor.		
Supervision and foremen	$ 473.91	$ 3.16
Watchmen on engines	1,012.20	6.76
Excavating	1,370.89	9.16
Bracing	208.75	1.39
Sheathing	91.00	.61
Baling water	90.00	.61
Drilling	246.50	1.65
Blasting	34.25	.23
Building trestle	3.00	.02
Cribbing under shaft	5.00	.03
Concreting	286.69	1.92
Rigging up mixer	105.00	.70
Moving derrick	15.00	.10
Placing beams in shaft	76.10	.51
Backfilling	102.50	.68
Hauling materials	401.36	2.68
Total	$4,522.15	$30.21
Total cost labor and material.	$6,637.50	$44.33

Tunnels.

Total length east and west tunnels, 392.0 feet.

Material.		
Crushed rock	$ 174.24	$ .44
Dynamite and caps	75.00	.19
Wall tile for lining	724.66	1.84
Tools, etc.	125.00	.32
Cement	160.30	.41
Repairs	50.00	.12
Lumber	50.00	.12
Drain tile	42.14	.11
Power and lights	75.00	.19
Miscellaneous material	40.00	.10
Total	$1,516.34	$ 3.87
Labor.		
Supervision and foreman	$ 473.91	$ 1.21
Excavating	1,260.28	3.22
Drilling	104.00	.27
Blasting	84.75	.22
Bracing	229.13	.58
Laying tracks	142.20	.36
Excavating for drain tile	72.75	.19
Backfilling	375.63	.96
Laying drains	69.25	.18
Excavat'g for lining wall foundat'n	90.50	.23
Lining tunnel with tile, walls and arch	604.19	1.54
Concreting wall foundations	344.00	.88
Hauling materials	401.36	1.02
Total	$4,251.95	$10.84
Total cost, labor and material	$5,768.29	$14.71

Detail Cost of River Crossing—48-inch Distribution Main.

Total length of crossing, 1,526 ft.; channel portion, 868 ft.; tunnel and shaft portions, 658 ft.

Material.	Amount.	Per ft. in Channel	Per ft. of Crossing.
1,523 ft. of 48″ x ½″ and 48″ x ⅜″ riveted steel pipe	$16,591.85	....	$10.87
48″ gate and air valves	1,537.69	....	1.01
Lead, cast iron pipe & specials	287.27	....	.19
Fittings & incidental supplies	204.55	....	.13
Bolts, pins, steel and iron	1,001.47	....	.65
Timber, blocking and lumber	2,041.64	....	1.33
Cement for bag anchorage and shore wall	800.16	.94	.52
Sand for above, and for filling trench and coffer-dam	647.34	.77	.42
Burlap bags for anchorage	1,021.31	1.19	.67
Paint and coating material	66.36	....	.04
Cable	371.00	....	.24
Electric power for lights and pumping	48.77	....	.03
Coal for engine and shanty use	1,184.94	....	.77
Oil, gasoline, candles, waste	742.26	....	.48
Dynamite and leads	383.14	.45	.25
Tools, rope, derrick repairs, etc.	1,001.33	....	.65
Transporting machinery	194.55	....	.12
Repairs and parts	387.23	....	.25
Miscellaneous material	139.83	....	.09
Total	$28,652.69	....	$18.77

Drag Line Bucket Used for Filling Concrete Over Pipe.

Labor.	Amount.	Per ft. in Channel.	Per ft. of Crossing.
Excavating and dumping dredged material	$ 2,215.79	....	$ 1.45
Timbering, sheathing, etc.	1,358.84	....	.89
Hauling pipe and specials	728.79	....	.48
Hauling supplies and equipm't	3,210.90	....	2.10
Rigging up engines, cableways, etc.	4,062.04	4.79	2.66
Foreman and supervision	2,888.45	....	1.89
Building cribs, etc.	1,598.21	1.88	1.05
Transporting and setting cribs	315.95	.37	.21
Dredging with shovel	2,416.09	2.84	1.58
Dredging with drag line	4,801.61	5.67	3.15
Watchmen on engines & camp	1,473.20	....	.97
Boiler work on steel pipe	4,193.53	....	2.75
Blacksmith, tool work and repairs	1,203.61	....	.79
Cutting pipe	287.88	....	.19
Scraping, cleaning, re-cleaning and painting pipe	481.31	....	.32
Setting 48-in. gate and expansion joints	121.50	....	....
Setting air valves	7.50	....	....
*Laying and erecting pipe in tunnel and shaft	898.68	....	.59
Anchor'g pipe with filled bags	1,490.86	2.20	.98
Unwatering coffer-dam	497.70	.59	.33
Concreting east shore	298.05	....	.20
Pulling pipe into channel	691.43	.82	.45
Moving materials	223.56	....	.15
Miscellaneous work	688.83	....	.45
Total	$36,154.31	....	$23.69
Total cost, labor and material	$64,807.00	....	$42.46

*Unit cost for laying and erecting pipe in tunnel and shaft was $1.37 per foot.

Detail Cost of 48-inch River Crossing, Pipe, Shafts and Tunnels.

Material and Labor.

Length of crossing, 1,526 feet; channel portion, 868 feet; tunnel and shaft portion, 658 feet.

Vertical feet of shafts, 149.7. Length of tunnels, 392.0 ft.

Total cost of pipe and crossing	$64,807.36
Total cost of shafts	6,637.50
Total cost of tunnels	5,768.29
Total	$77,213.15
Cost per foot of pipe in crossing	$50.60

The work was done entirely by the city's forces, as all work in Minneapolis is done by the day-labor system, and contracts are only let for material.

The pipe was furnished by the East Jersey Pipe Company.

Mr. J. A. Jensen, Assoc.M.Am.Soc.C.E., supervisor, was in direct charge.

ENGINEERS DISCUSS RAILWAY PROBLEM.

MEMBERS of the Saskatchewan Branch of the Canadian Society of Civil Engineers held a meeting Monday evening, May 21st, to discuss Canada's railway problem. L. A. Thornton, chairman of the Branch, who was the first speaker, said that the railway problem was, indeed, a big one, and, he might even say, a vital one for this country. The country could not jump at conclusions in a matter of such importance. Every aspect of it must be carefully studied to allow public opinion to express itself freely. The Canadian Society of Civil Engineers had always, and particularly since the beginning of the war, shown a keen interest in all the great questions of the day, and had given all possible assistance in the working out of the vital problems this country has had to face.

Mr. Thornton then referred to the great work accomplished by Mr. W. F. Tye, former chief engineer of the C.P.R., who had, in a paper that would be read to the meeting, explained what he thought was the best solution of the railway problem in Canada.

It must, however, not be forgotten, said Mr. Thornton, that after the war the people will have to bear many heavy burdens besides the financing of the railways, and even if the public were in favor of the government taking over the railways of the country, the people should be given every opportunity of studying the matter very closely so that they might know exactly where they were going.

O. W. Smith then read Mr. Tye's paper, remarking that Mr. Tye's work was one of which not only he himself, but all his colleagues and confreres, might very well be proud.

The "Regina Daily Post," in reporting the meeting, says:—

"H. S. Carpenter next read a paper on the same subject, prepared by Sir Thomas Tait, and which was published in full in *The Canadian Engineer*, of April 12th, 1917. He remarked that Sir Thomas Tait, contrary to the idea expressed by Mr. Tye, would have included the C.P.R. in the consolidation of the railways if such consolidation was to be the solution of the problem, as he considered it would be unfair to the C.P.R. to exclude it and force it to compete with a strongly consolidated railway organization.

"J. U. de Stein was then called upon to read a paper on the majority report of the Railway Enquiry Commission. E. J. W. Montgomery read the minority report of the commission.

"After Mr. Thornton had remarked that the many papers that had been read went to show the deep complexity of the question, and had pointed out that the matter should be given as much publicity as possible to allow the public to form a definite opinion on the whole matter, he declared the meeting open and invited everyone to express their views on the subject. After some of those present had differently commented on the suggestions contained in the various papers, the meeting concluded."

GRANITE BLOCK PAVEMENTS.*

By William H. Connell,
Engineering Executive, Day & Zimmerman, Philadelphia.

IN order to obtain the best results in granite block construction, the first step naturally is to determine upon the specification for the block itself. The American Society of Municipal Improvements have adopted the following specifications for a standard block, as being cut by the majority of the quarries in the United States:—

The blocks shall not be less than 3½ inches or more than 4½ inches wide on top, not less than 4¾ inches or more than 5¼ inches in depth and not less than 8 inches or more than 12 inches long. The blocks shall not show a variation of more than ⅜ inch on the head under a straight edge. They shall be so cut that they can be laid with joints not exceeding ½ inch in width.

The Borough of Manhattan, New York City, has adopted the following specifications:—

The block shall be not less than 6 inches or more than 10 inches long; not less than 3½ inches or more than 4½ inches wide, and not less than 4¾ inches or more than 5¼ inches deep. The contractor shall select a definite width for the blocks to be used on each city block within the limits of this contract and notify the engineer of such selection. All blocks shall be of the selected width with an allowable variation of ¼ inch either way from this width, but within the limits for width of blocks specified above. The blocks shall be approximately rectangular on top and sides and uniform in thickness. They shall be so cut that the joints between individual blocks when laid shall average not more than ⅜ inch. The head of the block shall have no depression greater than ¼ inch from a straight edge laid in any direction and parallel to the general surface of the block.

The city of Philadelphia has adopted a specification which is a mean between the specification adopted by the American Society of Municipal Improvements and the Borough of Manhattan.

Great care should be taken in the handling of the blocks to avoid chipping. Arrangement should be made to carefully unload the blocks from the boats or cars and immediately place them in the conveyances to haul them to the site of the work where the same care should be exercised in their unloading and handling. Rear-end dump vehicles should be used, as drop-bottom wagons unnecessarily damage the blocks. In all cases, the rehandling of blocks should be reduced to a minimum.

It probably appears to the ordinary layman as though there is no great necessity for requiring an inspector with any great ability in connection with laying granite block pavements and it is easily seen how one could hold such an opinion, as the blocks are cut at the quarry to conform to the specifications, and it is only necessary to lay the sand bed or cement mortar bed on a concrete foundation of the required thickness and pour the joints with either cement grout or a bituminous filler. This, of course, sounds very simple, but in order to obtain a first-class job it is absolutely necessary to be more than particular concerning a number of the essential details, without which a first-class pavement is out of the question.

The standard practice to-day specifies either a 1-inch sand cushion or 1-inch 1:4 cement-sand cushion laid dry. A number of the larger cities are rather inclining to the cement-sand cushion in preference to the ordinary sand

*Abstracted from paper read before the Fourth Canadian and International Good Roads Congress.

cushion as it is felt that weaknesses are less apt to develop due to shifting of the sand cushion. The Borough of Manhattan, New York City, the city of Baltimore, the city of Philadelphia and a number of other localities have recently adopted the cement-sand cushion.

The standard practice with reference to the grout for the joints calls for a 1:1 cement grout mixture. There have been a number of experiments in recent years with a mixture of bituminous material and sand for fillers. These experiments were undoubtedly carried on more extensively in the Borough of Manhattan, New York City, than any other place and to a somewhat limited extent in the city of Philadelphia and other cities.

These fillers consist of different mixtures, ranging from 30 to 40 per cent. of sand mixed with bituminous material—either tar, asphalt or asphalt and tar mixed. In Baltimore, they have obtained very good results with an asphalt filler used in the following method: They pour hot asphalt to a depth of 1 inch, about 1 inch depth of hot gravel, and repour and refill with hot asphalt and hot gravel alternately until the joints are flush. I am informed that this usually takes approximately four pourings. After the joints are filled, the hot asphalt is squeegeed over the entire surface of the blocks and hot gravel is then thrown over this before traffic is allowed on the pavement. This gives an asphalt surface of about ⅛ of an inch on top of the granite block, giving the street the appearance of a sheet asphalt pavement.

The best results in granite block construction are undoubtedly obtained with the cement grout filler, and it would seem to be good practice in every instance to make arrangements to close the street the additional seven to ten days and construct the pavements with grout fillers. Of course, there are some streets that it is practically impossible to keep the traffic off for this length of time, and in such cases it will be necessary to use the bituminous filler, but there are a number of instances where bituminous filler is used, where the traffic conditions have been such that the street could be closed for a long enough time to use the cement grout filler.

The old method in using cement grout filler was to fill the joints for a certain depth with pea gravel and then pour the cement grout filler. It has been found, however, that better results are obtained by eliminating the gravel entirely and filling the whole joint with the 1:1 mixture, and this method is used exclusively in a number of cities. There has been considerable discussion relative to the best means for mixing the grout. Of course, just as good grout can be mixed by hand as by machine, provided it is given the proper attention, but more uniform results will be obtained by adopting the machine-mixing method, as this eliminates the human element which often is not properly controlled.

The cement grout, of course, must be kept thoroughly agitated until it is poured into the joint, and the blocks should be thoroughly sprinkled before the filler is placed in the joints.

All of these essential details which, carried out to the letter of the law, go to make up a good pavement, appear to be so simple that in many cases the inspector and the workman are more or less lax, the result of which will show in the construction immediately after it is completed or within the next few years. A good job can only be obtained by strict attention to these apparently trivial but very essential details in the construction. The pay of inspectors on highway work usually ranges from $3.50 to $6 per day, and most engineers with experience will bear out the statement that a thoroughly capable inspector, judged by the standard of the average highway inspectors, is worth $10 per day to the community. A great many of the failures in paving construction are due, not always to dishonest inspection but careless inspection, and it would seem as though this branch of the service has not been given the consideration it should, and if it is necessary to pay $10 per day to obtain the right kind of inspectors, it would be far better to do so than to lose more than the increase in salary through poor work as obtained through careless inspection.

Of course, it is perfectly obvious that in order to lay good pavements we must eliminate all possible conditions that are liable to result in failure. In doing this, we must also take into consideration the human element and provide for methods of construction that will, as far as possible, eliminate the personal equation entering into the construction; or, in other words, we should not depend any more than is absolutely necessary, in such an essential matter as this, on perfect workmanship.

Some question has been raised relative to the tests for granite block. Some cities specify that the blocks should come from certain definite quarries, or from a quarry that will be acceptable to the engineer. There should be a more definite method in stipulating just what the requirements should be than to leave it up to the personal judgment of the engineer. After making an inspection trip of the different quarries and an investigation of stone laid by those quarries, it has been determined to make the test for the Philadelphia specifications as follows:—

Compressive Strength.—The granite shall have a compressive strength of 16,500 pounds per square inch, except when unusually heavy traffic conditions are to be encountered, in which case the compressive strength shall be 20,000 pounds per square inch. It is understood, however, that a strength of only 16,500 pounds will be required unless definitely stated otherwise in the proposal. The toughness shall be not less than 11, as determined by the method employed by the United States Department of Agriculture.

However, it might be stated that these requirements are not entirely satisfactory. Very extensive studies and tests are being made in Philadelphia at the present time to determine upon new standard tests that will insure satisfactory results. Of course, it must be borne in mind that on streets such as West Street in New York, where you have an enormous amount of heavy steel-tired trucking, that it is desirable to use the hardest granite that can be secured, but at the same time not be so hard that it will be brittle and chip, and on such a street it might be desirable to raise the crushing strength to at least 30,000 pounds. However, the New Hampshire and southern granites that test from 15,500 upward are entirely satisfactory for probably 95 per cent. of streets where it is desirable to use a granite block pavement. The Worcester, Mass., pavements, which have been in service upwards of 15 years, and have had practically no money spent on them for repairs, are the softer granites and they have proven entirely satisfactory on heavy traffic streets.

A very important matter in the construction of granite block pavements is the proper ramming of block. Where the specifications do not state the number of rammers that shall be employed to follow up the work of a definite number of pavers you will invariably find that the ramming of the block is neglected and that the contractor will employ just enough rammers to slightly ram each block. Of course, the pay for rammers is about $3.50 per day, and the fewer the contractor has to employ the cheaper the

work can be performed, so that instead of stating that the blocks must be thoroughly rammed, it is most important to state the relative number of pavers and rammers that shall be employed, as is stated in the following quotation from the Philadelphia specifications:—

Number of Rammers to be Operated.—On all granite block pavement construction the number of rammers to be operated shall be in the proportion of 1 rammer to every 2 pavers.

SOME GENERAL PRINCIPLES OF PHYSICAL VALUATION.*

By Geo. F. Swain, LL.D.,
Professor of Civil Engineering, Harvard University.

THE word "value" is one of the most uncertain in the dictionary of economics, and several distinct meanings are given in treatises on that subject. An object of little or no intrinsic value may have value for its possessor, but none for any one else; that is to say, its value may be entirely sentimental, and it would fetch nothing in the market. Again, an object of great intrinsic value, measured by its cost or by the cost of reproducing it, may have no value whatever in the market, because it possesses no sentimental value or no earning power; or again, an article or a property of little intrinsic value, measured by its cost or the cost of reproducing it, may have great value in the market because it has great earning power.

By the word "value" the economist usually means value in exchange; that is to say, the price which the article or property would bring as between a willing seller but one who is not forced to sell, and a willing buyer but one who is not forced to buy.

There is no sentiment about a commercial property like a railroad. The real value of such a property is measured by its earning power and by nothing else. No matter how costly or how inexpensive it may have been originally, its value in exchange will be measured by its earning power. Prospective earning power, perhaps under altered conditions, must of course be considered. Some properties, therefore, have a so-called "strategic" value, because, while they may earn nothing by themselves, they may be combined with other properties in a way to produce or enhance earnings.

If property is valued for the purposes of sale to a new owner, earning power, with the explanation above given, will therefore be the proper basis, taking account, in other words, of the uncertainties and potentialities of the future. This, however, would not be a physical value; that is to say, the value might include a large sum to represent location, good-will, patent rights or other elements which cost little or nothing, but which produce earning power.

In the case of a public utility corporation, a valuation is generally made either for the purpose of regulating capital, or for serving as a basis of rates to be charged, or for condemnation, or for purposes of taxation. For purposes of taxation or condemnation, earning power may be fairly taken into account. For purposes of fixing rates, which are themselves sources of earnings, it would clearly be reasoning in a circle to base the value upon earning power; for purposes of capitalization, earning power has clearly no direct or necessary connection; in these cases, it is the physical value of the property which is to be determined; that is to say, the value of the various physical elements which go to make up the property.

To determine this physical value there are two, and only two, available bases:—

(1) The original cost, or original cost less depreciation, according to circumstances;

(2) The cost of reproducing the property at or about the time the valuation is made, or, the cost of reproduction new less depreciation, according to circumstances.

These two bases are entirely distinct, and should be kept so throughout the valuation; whichever basis is adopted, it must not be confused, with reference to any of the elements of value, with the other basis, otherwise, confusion will result, and the conclusion arrived at will be unintelligible. If the original cost is to be found, it must be found without the slightest reference to what any part of the property would cost if reproduced at the time the valuation is made. If the cost of reproduction is to be found, it must be found entirely without reference to what any part of the property cost originally. The result will then be either the original cost, or the cost of reproduction new, and this result can be used intelligently and with due regard to circumstances, and as to whether it is a fair measure of value. Much of the confusion with regard to the subject of valuation has arisen from combining these two methods.

The valuation of a property is generally for the purpose of ascertaining what the courts have termed "the present value" or "fair present value." Just what the present value, or the fair present value may be, is not easy to state, and probably cannot be stated. The courts, however, have frequently stated what it is not. They have again and again laid down the principle that it is not original cost. In some instances they have stated that it is not the cost of the reproduction new, but it is generally admitted, I think, that both the original cost and cost of reproduction new, and also the depreciation, depending upon circumstances, are all elements which may affect the judgment as to the "fair value."

If the problem of the Railway Inquiry Commission were to determine the first cost of the properties which we have considered, this would have been a problem for accountants and not for engineers, except, perhaps, for some engineering advice on certain pertinent matters. The properties in question, namely, the Canadian Northern System and the Grand Trunk Pacific, have, for the most part, been constructed within a comparatively few years. To determine their cost would be purely a bookkeeping proposition, to be performed by expert accountants, with the aid of sworn statements, affidavits, vouchers, etc. Some of the lines of the Canadian Northern, however, are old lines which have been taken over into the system within recent years. I do not know what records are available, but it is very possible that to determine the original cost of these properties would be impracticable.

I have assumed, therefore, and I think it is clearly evident from the above brief discussion, that the problem assigned to me, that of making an approximate physical valuation of these properties, must necessarily be that of ascertaining the cost of reproduction new of these properties, and not the first cost. In other words, it is desired to ascertain what present investment in money may fairly be said to be represented by the physical properties concerned. If certain elements of value which originally cost little or nothing, like some of the real estate, have appreciated in value; the enhanced or present

*From report to the Royal Commission to Inquire into Railways and Transportation in Canada.

value is to be ascertained. If this was not the object, my valuation, as above stated would be unnecessary.

With the exception of the land, however, and those lines of the Canadian Northern System which are old lines recently incorporated into the system, in other words for the portions of the lines considered which have been built within recent years, the cost of reproduction and the original cost should nearly coincide. The land values themselves should probably not differ greatly, except in the large cities, where in some cases, land costing little originally has now become very valuable, so that its first cost and its cost of reproduction would be very different. In the case of the older roads recently bought and incorporated in the Canadian Northern System, the cost of these properties to the Canadian Northern Company might differ greatly, both from the original cost of the properties and from their cost of reproduction new at the present time. They may have been bought at very high or at very low prices, as compared either with first cost or cost of reproduction.

These principles were briefly discussed with the Commission before the beginning of the work. The problem, therefore, to be performed by the force under my direction, was to ascertain the cost of reproduction new of the properties in question at the present time. By the phrase "at the present time" is not to be understood the present moment, in view of the inflated prices for materials and labor which have come about as a result of the war; but rather, the fair cost of reproduction new, assuming that the properties were to be reproduced at fair average prices prevailing during a brief period of years just before the war.

LAKE OF THE WOODS REPORT.

The members of the International Joint Commission, when at Detroit recently, signed the report on the Lake of the Woods levels, and it is expected that this report will be delivered to the Canadian and United States governments this week. The two officers of the commission are now engaged in getting into shape some material supplementary to the report. It is probable that the report will be made public at an early date by the two governments. It is understood that accompanying it will be nine volumes, three of which are the consulting engineers' reports and maps and the remainder consisting of testimony and arguments.

That the United States Steel Corporation has appropriated up to date about $9,000,000 for building the company's Canadian plant at Ojibway, Ontario, is a statement made by Judge E. H. Gary, chairman of the company, to *The Canadian Engineer*. The construction on foundations, docks, etc., has been commenced.

The Manitoba government has established a purchasing department. Everything required by any of the departments will be requisitioned and put through the purchasing department. The head of the new department is Mr. E. A. Gilroy, former auditor of purchases, and he will be known as the government's purchasing agent. Mr. H. Hurd will be the assistant purchasing agent.

The British government is taking more ships from the Pacific routes and the Empress vessels of the Canadian Pacific Railway may be diverted. The ships being taken off the Pacific are being used for the greater part on the North Atlantic to carry foodstuffs and munitions to Britain, France and Italy. Some may be used during the open shipping season at Archangel, Northern Russia.

TAKING TRAINS TO THE TRENCHES.

DOUGLAS S. ROBERTSON, special correspondent at the front for the Toronto "Evening Telegram," has written an interesting account for that paper of the construction and operation of narrow-gauge railroads behind the fighting lines in France. He says that where the guns are roaring Canadian railway building is proceeding with all the push and go it ever exhibited on the western prairie. But the engineers and contractors have stars on their sleeves, and the men are all in khaki.

Canadian railway battalions are now handling the greater part of the railway construction behind the British front. Of the five assistant directors of light railways, no less than three are Canadians. Shells are delivered by rail right to the guns; rifle ammunition is hauled within a stone's throw of the firing-line; food and materials of all kinds are readily despatched to wherever needed; wounded are carried quickly to the base; and troops are shifted to and fro. Motor transport behind the lines has cost some fifty cents per ton per mile, says Mr. Robertson, whereas by railway the cost is about one cent, and, although the motor transport serves its useful purpose, the railway is more reliable.

Twisting and twining in sinuous curves, the light railways reach out to all parts of the battlefield. Every spur is constructed with double loops, so that should shell fire or other mishap destroy one loop, the alternative loop may be used. So numerous are these light lines, and so well planned, that traffic can never be altogether held up under any conceivable circumstance of mishap. They fairly gridiron the country back of the lines.

Stopping at a safe distance in the rear, the standard gauge lines unload their tonnage at the various ammunition dumps, whence it is moved to the trenches and the guns as required. The locomotives are largely steam-driven 17-ton Baldwins. The cars for the most part are like small editions of the Gondola coal cars. They measure 17½ ft. long by 5 ft. wide and are equipped with hand-brakes. These cars have a capacity of 21½ tons. By virtue of collapsible sides they can be transformed into flat cars. The railways are largely operated by despatchers, who use the telephone system.

Grades are fairly easy on these light roads. There is no rise greater than 1½ per cent., and no sharper curve than 20 per cent. There are some large cuts and fills. Broken stone and brick are used extensively for ballast, as a firm roadbed is necessary when moving heavy loads of shells. Many of the ties are cut in the woods of France by Canadian forestry battalions.

Although the light lines are built and maintained by Canadians, they are largely operated by British, Australian and New Zealand troops, enlisted specially for such work. Each repair train carries an electric generator, driven by a gasoline engine. These repair trains consist of a considerable assortment of machines, such as shapers, lathes, metal saws, drills, grinders, etc., all electrically driven.

"Tamping ties and driving spikes," says Mr. Robertson, "running transits and taking levels, the laboring and the professional sides of railroading, may be prosaic enough occupations at home, but here they are not only useful in the highest degree, but also they are fraught with no small portion of the soldier's risk. Every bullet has its billet and every shell its destiny. And not a few Canadians made the great sacrifice when helping to win the war with railroads."

MONTREAL AQUEDUCT REPORT

Steam Plant Would Have Been Better Than Enlargement—Report by Messrs. Vautelet, St. Laurent and McRae

(Continued from last week's issue.)

IN the case of abandoning the power development, there is no land available for boulevards and the aqueduct is used only to bring water to the pumphouse of Atwater Avenue.

We have, however, included the cost of finishing the south wall to the rock cut to correspond to the north wall ($43,300) to allow of the completion of the aqueduct at some future time, if it is ever deemed advantageous.

We have also included an arbitrary amount of $279,575, being 15 per cent. of the cost of the uncompleted part of the contract. This amount may be increased or decreased in the final settlement with the contractor.

We have included, as we have done in all cases, the interest until the completion of the work, although the city is not allowed to charge interest to capital account. In this case it amounts to $1,072,948. We have estimated the cost of abandoning the work at $5,895,000.

Scheme 1.

Present city scheme, but with mean velocity in headrace limited to 1.5 feet per second.

From the preceding considerations in studying the power obtainable, as based on the present plans, under winter and summer conditions, leaving out the question of frazil, we have assumed the mean velocity at 1.5 feet per second (1.02 miles per hour) in the headrace, on account of the nature of the earth bottom.

As it is intended to provide a substantial paving for the bottom of the tailrace, a velocity of 8 feet per second (5½ miles per hour) will not be excessive, and we have adopted this figure as the maximum mean velocity in the tailrace.

It is assumed that in winter there will be an ice covering of two feet in the headrace, though it is possible that during excessively cold winters, a slightly greater thickness of ice may form.

In the tailrace, on account of velocities being higher than 3.5 feet per second (2.4 miles per hour) there will be no ice covering in winter.

This power has been calculated for normal conditions, winter and summer respectively. Floods and frazil will cause unfavorable conditions from time to time, probably every year, either on account of loss of head or decreased flow, and it is to be distinctly understood that at such times the power stated will be considerably reduced. The only remedy against floods and frazil troubles is an auxiliary steam plant which must form a necessary adjunct to the water power scheme under consideration.

We find that for the limiting velocity of 1.5 feet per second (1.02 miles per hour) in the headrace, and under other conditions mentioned above, the power available, as based on the lowest winter month, and the lowest summer month average gauge readings respectively, at both entrance and outlet gauges, is as follows:—

Winter	7,445 h.p.	5,600 e.h.p.
Summer	11,900 h.p.	8,900 e.h.p.

The headrace is the controlling factor in both cases; that is, the tailrace, as designed and paved all through, is large enough to pass all the flow of the headrace, with velocities well under the limit of 8 feet per second as fixed. In fact, the highest velocity produced in the tailrace under this scheme will not be over 6.2 feet per second.

We have assumed that the summer power of 11,900 h.p. will be available for 7 months, so that during the 5 winter months the power of 7,445 h.p. will be available, say, for 2.6 months, and that there will be no water power available for the balance of the 2.4 winter months, pumping during the periods of deficiencies being done by the auxiliary steam plant.

We have shown before that the city will, in the near future, need to pump a daily average of 100 million Imperial gallons of water for domestic supply. The power required for pumping this quantity of water will be 8,570 h.p.

In this scheme there is no paving provided for the headrace and as paving will certainly be required in a good many places, the velocity could then be increased. If this were done, Scheme 1 would practically become Scheme 2.

The filtration plant at its present capacity of 50,000,000 Imperial gallons per day when placed in operation will require 2,960 h.p. for pumping and for electric heating, as at present installed. When it is increased to a daily capacity of 100 million gallons, the power required for both pumping and heating will be 3,270 horse-power. The filtration plant could be heated by exhaust steam from the auxiliary plant at a greatly reduced cost, as compared with electrical heating.

With this change in the heating system the filtration plant will require 1,910 h.p. for pumping when the capacity is increased to 100 million gallons per day. The plant under Scheme 1 must then produce power as follows:—

Needed for pumping 100 M. I. G. per day...	8,570 h.p.
Needed for elec. current for filtration per day	1,910 h.p.
Total	10,480 h.p.

During the summer period, say, for 7 months, the water power development will take care alone of the above requirements. During the winter period the development will require the help of a steam auxiliary, and our estimate for the scheme to meet all conditions is given below:

	Total cost.	Operation cost.
Actual needs	$8,537,000	$590,000
Future needs	9,177,000	679,000

The amounts charged for interest are, in the first case $1,200,744, and in the second case $1,231,234. This project includes the cost of land for boulevards and the cost of Lasalle Bridge.

Scheme 2.

Winter power, 13,000 h.p.; summer power, 24,500 h.p.

In Scheme 2 we have considered possible improvements to the present scheme, and have studied the conditions which will give a maximum practical hydraulic development for the city. This scheme is based on the following assumption and alterations to the present scheme:—

The headrace remains the same, excepting that the earth sections are paved with concrete and the sides of the rock cut below the gravity walls given a straight and smooth concrete facing instead of the irregular concrete finish called for by the specifications.

The paving we have considered is the same as specified in paragraph 38, page 8 of the specifications for contract No. 2.

The surface ice in winter is assumed to be two feet thick.

The tailrace is radically changed. It is widened from 113.85 feet to 172 feet; the bottom is paved with concrete one foot thick, and the grade altered from 4 feet to 2.5 feet in 2,900 feet, the bottom at the outlet remaining at elevation 2.00 above datum.

Under these conditions we estimate that the scheme is capable of the following power development: Winter, 13,000 h.p. (This power is subject to decrease or interruption on account of frazil or anchor ice. It is based on the lowest average winter month for 19 years (1895 to 1914); velocity in headrace, 2.82 feet per second); summer, 24,500 h.p. (Based on the lowest average summer month in two years, which is the only period of time for which we have any gauge records).

The maximum mean velocity in headrace is limited to 3.25 feet per second. The velocity in tailrace is limited to 8 feet per second.

We have estimated for a development of 13,000 h.p. winter and summer, which will be used as follows:—

Needed for pumping 100 M.I.G. per day....	8,570 h.p.
Needed for elec. current for filtration per day	1,910 h.p.
Total needed	10,480 h.p.
Excess power	2,520 h.p.
Total	13,000 h.p.

As in the case of Scheme 1, this hydraulic development must be supplemented by an auxiliary steam plant to provide power during times of ice and frazil troubles.

It is also assumed that the 13,000 h.p. above mentioned will be available for seven summer months. During the five winter months we have assumed that on the average there will be a decrease in hydraulic power equivalent to a complete shut-down of 2.4 months each year; during that time power will have to be furnished by the auxiliary steam plant.

Additional power over the 13,000 h.p. may be produced during the summer only, at a cost of $5.06 per h.p. or $6.74 per e.h.p. It has no market value.

We have not taken it into account in our calculations, except by providing foundations for a future extension to the power house, should it be decided later to utilize this additional summer power.

Thirteen thousand horse-power will pump a yearly average of 124,000,000 gallons per day, but in that case the summer average will be 142,000,000 gallons per day, and the auxiliary steam plant shall have to be used during the summer.

If instead of developing 13,000 h.p., 2,000 h.p. are developed in addition, out of the additional 11,500 h.p., then the summer average of 142,000,000 can be pumped by hydraulic power and the cost of operation on the h.p. basis will be reduced from $56.90 to $50.35.

Part of the balance of 9,500 h.p. may also be used to pump large quantities of water during the summer only, to provide water for fountains, parks etc., and to clean the streets. This water can be pumped at a cost of $3.20 per million gallons.

Another part of the balance might also be used for refrigeration of cold storage warehouses or to manufacture cheap ice. We have estimated from accurate data that the capital cost required for an ice manufacturing plant of a capacity of 300 tons per day, during seven months, if located at Atwater Avenue, would be $337,000. This amount might be diminished by about $60,000, if the buildings of the present pump-house (which would then have been moved near the filters) were used for the ice plant and as a garage for the motor trucks used in its transportation. This plant would manufacture ice from filtered water, at a cost of 54c. per ton. We have estimated that the cost of delivery at different central places, such as the bath houses of the city, would be about 45c. per ton, so that the cost of ice delivered (not distributed) would be about $1 per ton. One ton would provide 100 blocks of 20 lbs. of ice at a cost of 1c. per block.

We have calculated the cost of developing 13,000 h.p. summer and winter, as follows:—

Total cost	$10,609,000
Cost of operation	740,000
Amount charged for interest	1,299,398

Scheme No. 3.

Summer power	9,500 h.p.
Winter power	5,000 h.p.

Scheme No. 3 provides for enlarging the headrace with sloping banks without boulevards; the tailrace is the same as provided for in Scheme No. 1.

We limit the mean velocity in the headrace to 1.5 ft. per second. Two feet of surface ice will form in winter.

The lowest average summer month in two years is November, 1908, when the power produced would have been 9,500 h.p. The headrace is the controlling factor, and the velocity in the tailrace is 4.1 ft. per second.

The lowest winter month is March, 1912, when the power produced would have been 5,000 h.p., with headrace as controlling factor.

That part of the headrace situated in the rock section, 6,000 ft. in length, will be practically as shown on present plans, except that on the south side the bank will be sloping above the lodge instead of being supported by gravity walls as on the north side, where they are built.

In the east earth section, for a length of 14,000 ft., the banks slope 2 to 1. Between stations 140 and 128, the width at bottom will be 130 ft. Between stations 128 and 44, the width at the bottom will be 91 ft.; this section will govern. Between stations 44 and 0, the width at the bottom will be 122 ft. We have estimated the cost of Scheme No. 3 as follows:—

	Actual needs.	Future needs.
Total cost	$7,515,000	$8,205,000
Cost of operation	504,000	648,000
Interest charged	1,152,076	1,184,024

In this scheme there is no land for boulevards; the walls are built only in the western earth section, and the tailrace is built only large enough for the production of 9,500 h.p. It could be increased in capacity at some future time, as per Scheme No. 2, but in that case the tailrace would have to be enlarged and the walls demolished, and new bridges required for Wellington and Buffalo.

Cost of Pumping by Steam. (Scheme No. 4.)

In this scheme there are no boulevards. To pump 100 million Imperial gallons per day, we calculated, first, the cost of adding two new DeLaval pumps and new boilers to the existing plant.

The existing plant has been lately valued by Supt. Lesage at $674,000. With additions, its total value would be $1,032,690, and the cost of operation $494,924 per annum. We have also estimated the cost of an entirely new plant, consisting of six DeLaval units of the same capacity, with new boilers, buildings, etc.

The capital cost is $769,240, and the operating cost is $369,744 per annum.

There is, therefore, a difference in favor of the new plant of $125,180 per annum, and, even if we add 5 per cent. of $674,000 to cover the dead loss of the old plant, the difference will still be $91,480 per annum in favor of a new plant.

This difference would, in reality, be much larger, owing to the necessity of remodelling the old plant, and to the difficulty of supplying water to the city during the remodelling.

When the work is completed it is planned to have the water flow by gravity from the filtration plant to the steam pumps, increasing the suction by about 12 feet. If the steam plant is not to be altogether discarded it will have to be remodelled to suit the new conditions and considerable piping shall have to be done.

The best location for the steam pumps would be near the filtration plant, as that plant could be heated by exhaust steam, instead of electricity as it is now.

The current used for heating by electricity is paid by Tariff I. of the city. When the addition to the new plant is made (and this should be done at once) the cost of heating would be at actual rates, at least $25,000 per annum. This amount would be saved each year by using exhaust steam. Large quantities of steam will be available for heating, if required, at no extra cost.

We have estimated the cost of pumping by steam as follows:—

	Capital cost.	Cost of production.	Interest charged.
Actual needs	$6,434,000	$546,000	$1,098,590
Future needs	6,703,000	712,000	1,111,411

The plant we have estimated on, which employs DeLaval pumps, hand-fired boilers and cheap fuel, as designed by Supt. Lesage, gives excellent results, but the cost of labor, which is, in this case, an important item, might be diminished by the use of mechanical stokers. In that case we have estimated the saving at $24,000 per annum, and the increase in capital cost at $56,000. As the saving would be the same for all schemes, except Scheme 5, we have left it out of our calculations.

Cost of Pumping by Electricity. (Scheme 5.)

In this case we have used for the cost of electric current the rate of $30 per e.h.p., according to the present contract with the Montreal Light, Heat and Power Co.

At the request of Commissioner E. W. Villeneuve we wrote to the companies supplying electric power in Montreal, and enclosed Mr. Villeneuve's letter, asking at what rate the companies would be prepared to supply the city with power per day of 24 hours for a period of 25 years.

We received two letters from the Montreal Light, Heat and Power Co., advising they would be prepared to undertake the street lighting of Montreal at the present prices for a period of 40 years from date, and also quoting tentatively for 3-phase alternating current, 11,000 volts, delivered at the city pumping plant, Atwater Avenue, $25 per annum per h.p. (probably e.h.p.) of maximum demand on the basis of a 20-year contract, and $24.50 per annum per h.p. (probably e.h.p.) of a maximum demand on the basis of a 40-year contract. This for 24 hours' service.

The current which is now furnished to the city for 24 hours' service is of two kinds:—

1. A current of 2,200 volts in units of 400 e.h.p. or more at a cost of $30 per annum.

2. A current of 2,200 volts in units of from 100 to 399 e.h.p. at $35 per annum.

Current at 11,000 volts would have to be stepped down for use, and to the price of $25 would be added the operation cost of transformation and electric losses.

The average pumpage at Atwater Avenue is at the rate of 54,000,000 Imperial gallons per day. On account of the insufficient reservoir capacity the output varies from 73,000,000 maximum to 45,000,000 minimum. This variation greatly increases the cost of power for operating.

When the city buys power from a company for pumping the company must be ready to deliver it for the peak load at any time, and very properly charges for the said peak load all year long at $30 per e.h.p. For instance, at the McTavish pump a test was made, showing that the pump, working at full capacity for two hours, was pumping at the rate of 5,760,000 gallons per day, and used 523.5 e.h.p. The city paid $15,660 for power used at McTavish Street in 1915, or for 522 e.h.p. at the rate of $30 per annum. During that year the average daily pumping was 4,620,000 gallons, which requires about 420 e.h.p. The cost of this average power is, therefore, $37.35 per e.h.p., or an increase of about 25 per cent.

At Papineau Avenue, where the nominal rate is $20 per e.h.p. per annum, the cost of power actually used was $27.72, or an increase of 38 per cent., the difference between the percentages of increase being due to the respective efficiencies of the pumps.

In the absence of complete details of the terms on which electric power would be supplied for this service we have based our estimates on the following:—

First—Buying power at $30 per e.h.p., maximum demand.

Second—Buying power at $25 per e.h.p., maximum demand.

(As per terms of present contract.)

	Total Cost.		Cost of Operation.	
	Actual.	Future.	Actual.	Future.
	$	$	$	$
Scheme 5 at $30 per h.p.	6,102,000	6,268,000	565,000	712,000
Scheme 5 at $25 per h.p.	6,102,000	6,268,000	529,000	656,000

The amounts charged for interest are:—

	Actual.	Future.
Scheme 5	$1,082,524	$1,090,191

It is recommended that at least two power transmission lines be installed to the pump-house in case of purchase of power. The present steam plant and its emergency intake is a further insurance against any serious interruption of your service.

We must point out that the maximum pumping occurs only during four months of summer, during which

time the companies have an excess of power, whereas in winter the maximum is very seldom above the average for the whole year, and it could easily be arranged never to exceed it. The power companies might possibly be ready to grant better terms to the city if the facts were better understood.

Electric Lighting.

We have seen that in case the filtration plant is heated by exhaust steam the power needed in the near future by the city will be as follows:—

Pumping at Atwater Avenue	8,570	
Filtration plant	1,910	
		10,480
Lighting		4,330
Total		14,810 h.p.

None of the schemes we have considered gives enough power for lighting. The only question before us, therefore, was to find out whether it would be cheaper for the city to buy power and do its own lighting, or have the lighting done by contract as at present.

We have estimated for the near future on 3,000 lamps of 6.6 ampères and 2,000 lamps of 4 ampères, as per Mr. Parent's report to you, dated Setpember 12th, 1916, assuming wires underground for a distance of 25 miles of streets and aerial distribution for 425 miles of streets.

We estimated that for the city to do its own lighting would require a capital cost of $1,670,000, and the cost of operation, not including the cost of current, would be $280,000 per annum, and that the cost of lighting by contract at present prices would be $365,000 per annum. This would leave a difference available for current of $79,000 per annum, or $18.24 per h.p., or $24.32 per e.h.p. at Atwater Avenue.

We must remark, however, that the price of current is a small item of the cost of lighting, but that the place where the current is delivered has great importance on this item, so that if the current could be bought by the city at $25 per e.h.p., delivered at sub-stations, the cost of doing the lighting and buying current and the cost of having the lighting done by contract would be equal.

It must be noted that should the city take over the lighting it will no doubt have to erect some 18,000 extra poles. This should be guarded against, and it is suggested that all the aerial systems be placed under the control of the commission now in charge of the underground work. There is no doubt that in that case the cost of lighting would be materially lessened.

We have seen that Scheme 2 has 2,520 h.p. available, and that there will be 25 miles of street with wires underground. The city pays for the lamp-posts, the cables laid in place, and pays also the rent of the conduits where the cables are laid. When the price of copper has become normal, the city might undertake that part of its lighting. For the time being it would be more advantageous for the city to continue to have the lighting done by contract, as at present, leaving the consideration for doing its own lighting for some future time, in case it could produce electric current at a lower price than it could be bought, and when the price of copper would have become normal again.

The amount of interest for each scheme shown in the following table must be deducted from the total cost of each scheme, as the city is not allowed to charge interest to capital account, but must charge it to current expenditure.

Financial Statement.

Loans authorized:		
Issued	$6,701,000	
To be issued	3,799,000	
		$10,500,000
Estimated discount		319,000
		$10,181,000
Less filtration works	$1,894,490	
" pumps	72,137	
		1,966,628
Amounts available for aqueduct		$ 8,214,371
Amortized at end of 1916		274,608

Interest Charges.

	Actual needs.	Future needs.
Work abandoned	$1,072,948	$1,072,948
Scheme 1	1,200,744	1,231,234
" 2	.....	1,299,398
" 3	1,152,076	1,184,924
" 4	1,098,590	1,111,411
" 5	1,082,524	1,090,191

Amounts Chargeable to Capital Account.

Work abandoned	$4,821,898	$4,821,898
Scheme 1	7,335,880	7,945,675
" 2	.....	9,308,752
" 3	6,341,728	7,019,290
" 4	5,334,723	5,591,137
" 5	5,019,150	5,177,077

Yearly Expenditure and Revenue of the Aqueduct.

Year.	Cost of operation and maintenance.	Ordinary revenue.
1904	$ 200,772	$ 836,537
1905	226,990	911,520
1906	237,939	972,586
1907	291,942	1,027,179
1908	288,178	941,611
1909	272,496	984,432
1910	391,676	1,051,047
1911	454,897	1,168,209
1912	663,769	1,328,029
1913	811,464	1,626,147
1914	1,036,375	1,414,192
1915	1,195,309	1,374,793

The cost of operation, maintenance, etc., does not include the interest on the invested capital nor any provision for amortizing or depreciation.

Remarks on Costs and Conclusions.

It must be clearly understood that we have estimated the cost of the different schemes on condition that they be executed with despatch, in a businesslike way and without undue delays.

We have found that the cost of putting the canal in proper shape if the work were discontinued is $5,894,846, of which $1,072,948 represents interest. We had, therefore, to charge $294,742.30, being the interest at 5 per cent. per annum on the said cost, to the cost of pumping by steam or of buying electric current (Schemes 4 and 5).

On account of fluctuating rates and prices, it is impossible at present to make an estimate of cost which would hold good for any length of time. This must not be forgotten in comparing estimates made as early as 1905 with those made now.

Total Cost and Cost of Operation for All Schemes.

(Power given in h.p.)

Schemes:	Power development. Potential hydraulic power. Summer.	Winter.	Pumping and electric power. Summer.	Winter.	Heating. Winter.	Total cost. Actual.	Future.	Cost of operation. Actual.	Future.
I. Present plan	11,900	7,445	10,500	10,500	Heating by exhaust steam.	$8,537,000	$ 9,177,000	$590,000	$679,000
II. Maximum power available	24,500	13,000	13,000	13,000		.....	10,609,000	.....	740,000
III. Minimum power available	9,500	5,000	10,500	10,500		7,515,000	8,205,000	504,000	648,000
IV. Pumping by steam	Nil	Nil	10,500	10,500		6,434,000	6,703,000	546,000	712,000
V. Buying electric current—									
$30 per h.p.	"	"	10,500	10,500	1,400	6,102,000	6,268,000	565,000	712,000
$25 per h.p.	"	"	10,500	10,500	1,400	6,102,000	6,268,000	529,000	656,000

The estimates referred to at the beginning of our report show a close agreement with our own, although calculated for different assumptions of the quantity of power obtainable from the canal, and for different methods of utilizing said power.

Our estimates do not include the cost of the filtration plant already built, nor of its proposed additions and operation, but include the cost of the power needed, and the cost of heating. We have not included either the cost of the main suction and discharge pipes beyond the pump-house; the cost of some of the bridges (as explained before) nor of the claims of the Cook Company. These costs would be the same for all schemes.

As for boulevards, which are provided for only in schemes 1 and 2, we have included the cost of land, fences and ditches, and whatever grading must be done by the contractor; and nothing else.

In this report five schemes are considered. The figures used are taken from works lately executed, with a percentage added to cover normal increase in cost of labor and materials.

The tables all indicate "present needs" and "future needs." We would direct your attention to the figures for "future needs" only, as such will be justified by the time the plant is ready for operation.

Cost of Schemes—(H.P. Basis).

	Total cost.	Capital cost.	Cost of operation.
Scheme 1	$874	$756.66	$64.66
" 2	816	716.06	56.90
" 3	782	668.50	61.71
" 4	639	522.48	67.81
" 5—			
Electric current at $30.	597	493.05	67.81
Electric current at $25.	597	493.05	62.47
Work abandoned	562	459.22	28.07

We will now consider the schemes as described.

Present Scheme (Scheme 1).

This scheme is the one to which exception has been taken, and we agree that it should not be proceeded with as outlined. It could not have developed the expected power.

Maximum Hydraulic Development (Scheme 2).

This scheme shows the cheapest cost of operation per h.p. It is described at length in the body of the report, and considered in our recommendations.

Minimum Hydraulic Development (Scheme 3).

This scheme is inferior to Scheme 2, and need not be considered. It gives less hydraulic power, and the auxiliary steam plant being worked to a much larger extent, the possible increases in the price of coal will affect the cost of operation to a greater degree.

Pumping by Steam (Scheme 4).

This scheme considers finishing the aqueduct simply as a channel to carry water to the pumps, which are operated directly by steam. The high cost of operation is due to the charges against it of money already spent on the aqueduct extensions. Had the old aqueduct been left as it was, simply as a supply to the steam pumps, a steam pumping plant would have been a most attractive proposition.

Buying Power (Scheme 5).

There are two subdivisions to this scheme, figured on electric power supplied at $30 and $25 per e.h.p., on the same basis as power is now purchased for pumping purposes.

Here, as in the case of scheme 4, the cost of operation is charged with the amount already spent on the aqueduct extensions. To this is added such expenditure as may be required to put the channel in condition to carry the water supply to the pumps. This scheme is again referred to in our recommendations.

From our examination we considered that it will be necessary to pave certain sections of the bottom between the walls, as a precaution against their sliding or turning over, due to the unstable nature of the ground. We have provided for such paving in our estimates.

Power for Lighting.

There is not sufficient hydro-electric power in sight at present to justify your considering the taking over of the city lighting. This question has been treated at length in the body of the report.

Filters.

The filters, as designed and now nearing completion, have a rated capacity of 50,000,000 Imperial gallons per day. We understand that plans are under way for a further extension to 100,000,000 Imperial gallons per day output, with possible future extension to 150,000,000 Imperial gallons. The present records show a maximum pumpage of over 70,000,000 Imperial gallons. This means that the filters have not sufficient capacity to meet the present demand.

(Concluded on page 488.)

Absence of Regulation Helped Create Railroad Problem

Says Minority Report of A. H. Smith of Railway Inquiry Commission—"The Scrap Heap is Frequently the Most Economical Disposition Available for Inefficient Plant and Machinery"—Status and Usefulness of the Three Transcontinental Railway Systems

A LENGTHY summary of the majority report of the Railway Inquiry Commission, and a part of the minority report have already appeared in these columns. Mr. A. H. Smith introduces his report by discussing the general problem of transportation in Canada. He says:—

For a proper understanding of the problem, a knowledge is necessary of the history of railway development in Canada, especially as affected by the public policy, which has found expression in governmental acts.

Canada early recognized that its growth depended upon the construction of railways. The large productive areas of the country could be served only in a limited way by its splendid system of waterways.

Even before the eastern provinces became united into the Dominion of Canada, the Grand Trunk had become an important railway line, serving the people both of Canada and the United States. The Intercolonial, as is well known, was constructed out of public funds, and largely for the purpose of bringing more closely together, commercially and politically, two more or less separated sections of the Dominion. Long in advance of its justification upon a commercial basis, an all-Canadian transcontinental line was projected by the Government and completed with extensive public aid by a private company as the Canadian Pacific.

Because of the great distances which separate parts of Canada's producing territories from the consumers' markets, development of the country's resources depended upon railway building, while cheap transportation was necessary to enable the people to compete with other producers. The people of Canada, therefore, gave such aid as was necessary to procure for themselves railway lines that would bring the country's resources into use and keep themselves in touch with the outer world.

Cheap transportation depends upon careful investment and efficient management. In the usual case, these are most likely to be found where private initiative and proper incentive to effort are employed. So far, Canada, for the most part, has pursued the policy of leaving to private enterprise the management of the transportation machinery. The Intercolonial, which has been under governmental control since its beginning, is an exception. But this line, I am informed, usually pays nothing to the government as a return upon money invested in the property. On the contrary, it has frequently called upon the government for aid in meeting expenses of operation. The investment in this line is large, some authorities placing it as high as $348,000,000, including loss of interest. Evidently its rates are too low or its expenses are too high, but the use of this line, at the rates enforced, is regarded in some quarters as a right of the people in the maritime provinces. If the Canadian people have ever made an agreement, or adopted a policy which may be construed as creating that right, the contention may be correct; it is, at any rate, within the power of government to grant such a privilege. The fact is referred to merely to point out in connection with what I shall say later that a railroad may be built either as a commercial enterprise and for ordinary commercial purposes, or as a public undertaking and for other purposes, which are within the proper scope of government. The two should not be confused. But it should be kept in mind that when government builds and operates a railway which does not pay its way, including proper maintenance and interest upon investment, taxation is relied upon to support transportation upon that line. The burden is shifted from the user to the general public, but the processes by which this is done are often so complex as to obscure the facts, and actual costs are not ascertainable.

Completed by Company.

The Canadian Pacific affords a later example of the internal development policy of the government. That road had its beginning in a transcontinental project that was proposed to be carried out directly by the government. At an early date, and it seems to me wisely, that purpose was altered; it was decided to have the road completed by a private company. But the undertaking was large, the population sparse, the prospect of profit remote, so that the government not only turned over to the company the uncompleted road upon which it had expended a large sum, but it also extended to the company generous aid in the shape of land grants, cash subsidies, guarantees, and loans. It is true that value was given to the land grants largely through the building of the road and the opening of the territory to settlement. The important point here is that the Canadian Pacific owes its later and continued success, not only to the skill and enterprise of its builders and managers, but to the fact that through liberal direct aid, it was able to begin business with a small charge against its earnings on account of borrowed capital. Thus favorably started, the company was able to devote its energies and surplus income to the development of the road and the country.

A new transportation problem arose with the settlement of the prairie provinces, where the land is devoted chiefly to raising grain and live stock. Owing to the long hauls that intervene between the producer and consuming markets, freight charges absorbed a considerable part of the proceeds. The Great Lakes afforded the least expensive route to the east and tidewater. But these lakes are open only part of the year, and navigation closes before the season's crops can be moved from the lake ports. With the filling up of the country and consequent increase in production, came a general demand for additional means of transportation. While land speculation probably had no little influence, the farmer felt the effect of inadequate facilities, and any project that promised relief appears to have found approval among citizens who were able, through their legislators, to bring public aid to the development of these enterprises. Railroads, therefore, were not only actively in demand, but railroad builders were popular and had little or no difficulty in obtaining public support for proposed new lines.

What Made the C.P.R.

The Canadian Pacific stood as an example of success to be repeated by newer railways. Unfortunately, too little attention appears to have been given to the underlying facts which actually made that road what it was. Experienced men apparently believed that a second Canadian Pacific might be had if they could but lay a transcontinental road, build great hotels, passenger terminals, and operate ocean steamers. These things were only the outward evidence and not the cause of Canadian Pacific's prosperity. It may even be that they contributed little to the strength of that company's financial condition, if due account be taken of all the costs, investment as well as operating, involved in carrying on such enterprises.

In May, 1903, a Royal Commission of Transportation, of which Sir William Van Horne was chairman, was appointed "to consider questions affecting transportation of Canadian products to the markets of the world through and by Canadian ports, with a view of placing the Canadian producer in a position to compete, and compete successfully, through all Canadian ports with the producers and exporters of other countries." The report of this commission is interesting. It clearly reflects the effect of the outlook which great opportunities and a land boom had upon the minds of the people. All kinds of transportation projects were recommended. For instance, the Grand Trunk Pacific was to be extended to Moncton the Intercolonial was to be extended to Georgian Bay, etc. New canals were to be built, and old ones widened and deepened. This commission also recommended a bounty for Canadian-built ships, toll-exempt canals, additional waterways to be opened at public expense, and the acquisition of water terminal lands out of public funds. In other words, it was clearly the intent that transportation should be stimulated by subsidies from the public treasury.

It would now seem that there could not have been in sight enough traffic to justify the extensive development here recommended. However, many of the things proposed in this report have been done, and other ambitious schemes not here mentioned have since been brought out. The point in mind is that without making a specific declaration of the fact, as far as I know, Canada's policy for years appears to have

been to promote the public welfare by means of building or aiding in the building of transportation lines throughout the Dominion.

It is unfortunate that Canada did not have a policy of regulation in this period which could have prevented needless duplication of lines and facilities. Competing lines have been built where effective regulation could have saved a large part of the investment, while completely satisfying every reasonable and proper need for service. Instead of co-ordination and conservation under government supervision, railways were permitted to duplicate plant in fields not yet productive enough to support the one; the government, on the other hand, was, in one way or another, aiding both projects, if it had not indeed itself promoted either or both projects. Very naturally, it has not and could not have obtained the benefit which should have followed a correct programme of government aid. The policy of government aid makes the need for regulation of railway building more necessary even than where private capital is depended upon, for in the latter case the proposal must at least have a promise of commercial success before capital can be induced to come in and give it support. To the absence of such regulation must be charged responsibility for no small part of the railway problem of to-day.

Effect of Policy.

We may well inquire here as to the effect of this policy upon the three principal systems. The Grand Trunk Railway Company, feeling no doubt that its own traffic field had been invaded by the government-aided Canadian Pacific, desired in turn to enter the promising western territory. Accordingly, it proposed to build a line from North Bay to the Pacific Coast. Public aid was required and granted in a way to ensure the building of the road. If any serious thought was given to co-ordinating existing or proposed roads, and to utilizing them for the public good, it did not find public expression in any constructive way. The Grand Trunk Railway Company evidently felt confident in the success of its plans, for it pledged its own credit in aid of the extension, and entered into contracts which it now finds quite beyond its ability to carry out.

Canadian Northern interests, directed by Mackenzie, Mann & Company, who since an early date had been operating local lines in Manitoba, seized the opportunity afforded them for expansion and rapidly extended their rails throughout the prairie region. The records show that the Canadian Northern had a large mileage on the prairies before the projection of the Grand Trunk Pacific; so that when the extension plans of the Grand Trunk became a part of the national policy, as they did become, the Canadian Northern was added to the number of those who wanted to own a transcontinental system and one as fully complete and self-contained as was that of the Canadian Pacific. Hence, we find two new companies, both built largely upon public credit, striving for first place in a field which, as for transcontinental transportation, or even as for connecting Eastern and Western Canada, was already occupied. Besides having the Great Lakes waterway, there could have been barely enough business to support one additional line, and that only by the exercise of economy in operation and prudence in investment.

Created a Boom.

The Canadian Pacific, enjoying splendid credit, with adequate powers and resources, and keenly alive to the possibilities of losing business to competitors challenging its supremacy everywhere, then entered the contest by undertaking to build new lines in an effort to protect its sources of revenues.

The stimulation felt throughout the country by the influx of settlers and by the importation of so much new capital not only created a boom, but it quite naturally affected prices for labor and materials, sending these soaring; the increased prices in turn contributed largely to the higher costs which are now reflected in the construction accounts of the new roads.

This brings us fairly to a recognition of the fact that while the policy of public aid to railways had originally been founded on the urgent need for transportation to open up a new country, to develop its resources, and to unify Canada commercially and politically, it was carried far beyond the limits warranted by the original exigency. It appears to me that the responsibility is as much the government's as the private companies'. Without enabling legislation and the extension of government credit from which all received their essential support, the companies could not have expanded and overbuilt.

This policy, in so far as it aimed at the development of Canada, appeals to me as sound, and fully justified in its inception, but it needed to be supplemented by some form of supervision that would have insured to the people the benefits of that policy without the losses that have followed the effort to assist development indiscriminately.

The situation must be faced as it exists. It is not possible to undo what has been done, the money which has been spent cannot be recalled. The immediate and obvious thing to do is to adopt a constructive and discriminating programme, first, for correcting the conditions which necessitate continuing loss and waste, even where that would require the abandonment of useless property, and, second, for controlling new construction. The scrap heap is frequently the most economical disposition available for inefficient plant and machinery.

Mr. Smith then deals with the status and usefulness of the three transcontinental railway systems, and says:—

The Canadian Pacific Railway is essentially self-contained and self-sustaining. I agree with my colleagues as to its financially strong position. It has world-wide commercial strength. As a result of the aid and privileges extended by government, together with the prudence and progressiveness of its managemnet, which has extended its field of activity over nearly all Canada, and through its steamship lines and commercial organizations throughout a large part of the world, it is a success.

Is Efficiently Operated

The Canadian Pacific is well built, well maintained and has adequate terminals and equipment. It is efficiently operated. It is somewhat at a disadvantage in crossing the mountains, and elsewhere it has gradients that, compared with more recently built lines, do not make for as good trainload and operating efficiency. It is assumed that the Canadian Pacific will make improvements as the need for them arises, for it is fully able to do so.

Accorded reasonable treatment, that company will continue, I am sure, to give good service, and I believe the best interests of Canada will be served by continuing the present status of the Canadian Pacific. The introduction of government railway competition, which might have no regard for investment or cost of operation, would be unfair and, in the end, would react disastrously upon the Canadian people. The regulating power affords to the people of Canada adequate protection in the matter of rates and services, and such power should likewise protect the company.

Grand Trunk System.

The fortunes of the Grand Trunk Railway Company are bound up with the Grand Trunk Pacific. It stands as guarantor for large sums of money invested in the railway, and has advanced millions from its own resources in an effort to develop the western line and its subsidiary properties. The Grand Trunk Pacific Development Company has absorbed many millions of Grand Trunk capital without definite prospect of return, and to the Grand Trunk Pacific Branch Lines Company large construction advances have been made. Not only is the Grand Trunk committed for many millions, but the government has directly invested large sums of money in this property and guarantees other large sums, the total of which exceeds $127,000,000.

The Grand Trunk Pacific was located on a scale that would do credit to any single-track line. There is not enough business to justify such an outlay, and the prospect for business which will warrant the cost seems quite remote. For long distances, sections of this line parallel one or more other lines.

The part of the Grand Trunk Pacific lying between the Rocky Mountains and the Pacific coast is in a country which appears to have abundant natural resources. In time, these may be developed to the advantage of this road.

The port of Prince Rupert is suited for a large ocean traffic, which is non-existent. The development of Alaskan trade seems to present the most immediate possibility for this port and railway.

The road west of Winnipeg has some disadvantages on account of expensive trestles and instability of enbankments. It has good grades, but inadequate terminals at important places. It has sufficient equipment but lacks feeders.

From the Rocky Mountains to Winnipeg, the presence of parallel road arises a question as to whether the Grand Trunk Pacific line is not the best adapted by location and physical

condition to handle the trunk-line traffic. If it is not the best, then the disposition of this part of the road, with its branches, naturally depends upon its usefulness as a road serving local interests.

From Winnipeg east to North Bay and Port Arthur, the Transcontinental and Grand Trunk Pacific railroads together can give efficient service as a connecting link between the railways of Eastern and Western Canada. This road also affords a good line for traffic moving via the Great Lakes. In fact, it is probably the best route of any for hauling bulk commodities at low costs.

Government Morally Bound.

Officers of the Grand Trunk Railway Company claim that the government is morally bound to relieve the company of the Grand Trunk Pacific, because the government is responsible for the failure of the project, having permitted a rival company to enter the field. The rival line, however, has been constructed at a lower cost per mile, and manages to get enough traffic to pay its operating expenses and a large part of its fixed charges, which cannot be said of the Grand Trunk's system west of North Bay. I feel that I am not called upon to discuss the merits of the Grand Trunk's claim against the government. I have no doubt the government has observed at least the letter of its contract.

Standing alone, with efficient operating conditions imposed there is no reason, within my knowledge, why the Grand Trunk Railway proper should not become a profitable operation. It occupies a good territory, reaching some of the best traffic centres in the United States and Canada, and has American connections that ought to contribute to its welfare. The company needs terminal improvements in cities and modern equipment, especially locomotives. The need for equipment is pressing, and should be met.

Canadian Northern System.

The lines of the Canadian Northern, particularly in the prairie provinces, appear to be advantageously located in view of traffic conditions. Inspection of the property brings out the fact that this road was built with proper regard for economy, and the creation of a permanent public service utility.

In some instances, the system has extended its lines where it should have obtained a traffic interchange agreement or the joint use of facilities instead, at least until the traffic had grown enough to justify further expansion. A public policy intended to develop and serve the country as a whole, at the lowest cost, would have enforced arrangements which would have obviated the needless duplication of facilities.

The line from Yellowhead pass to Vancouver, in part at least, may be unnecessary, but it is there by the joint action of government and the company. The character and capacity of this line through the Fraser River canyon, where it is alongside the Canadian Pacific for about 200 miles, would suggest that no more money should be spent for double-tracking or revising grades on either of the railroads for years to come. From Yellowhead pass to Edmonton, the proximity of the Grand Trunk Pacific places two lines where one affords abundant capacity.

Appears to Have Been Unwise.

The invasion of the east by the Canadian Northern now appears to have been unwise, but condemnation thereof must be tempered with a knowledge of the conditions which forced this extension. There was a public demand for railroads. All Canada was enthusiastic over the prospects of a rapid growth in wealth and population. Railroads were on a competitive basis, and the public stood ready to back any new railroad enterprise, since that meant a rival carrier, and, incidentally, a new business in construction. There was no regulation which enforced co-operation among rival lines. The Canadian Northern, seeking to expand and become a profit earner, quite naturally desired to get all the traffic it could, and to hold all it got for as long a haul as possible. As a result, it undertook to do what appeared to be necessary under the conditions then existing—that is, to extend its line to both oceans.

An inspection of this company's property shows that generally it is of a type of construction well suited to its needs, and that the builders have installed it at a cost which, by comparison, seems small. Nowhere was there evidence of waste in the construction work itself. It is true that the company had some construction under way, or planned, that appeared wasteful because unnecessary, but this is due, I understand, to the unregulated competitive system, or to bargains with public authorities.

The building of expensive terminals in cities already supplied with adequate facilities affords an example of duplication for which the public must eventually pay. However, in the absence of restraint and regulation by consistent public authority, it is difficult to determine how the company could have avoided this.

The precarious financial situation of the Canadian Northern is due, in part, to its uncompleted condition, and to the fact that needed capital cannot be obtained on its own resources, especially during the period when capital is so greatly in demand by powerful governments. This system is not at present able to earn all of its fixed charges. As important parts of the system have but recently emerged from the construction period, it would be truly remarkable if it were able to do so. It does earn a very large proportion of such charges, and probably could earn all of them but for the burden of eastern extensions and duplications that have been placed upon it. Practically all commercial enterprises, and particularly railroads, must go through a development period.

The Canadian Northern is short of equipment. With the return to normal conditions, and provided with the capital necessary for equipment and for additional local facilities, this road can, in my judgment, work its way out in a reasonable time.

CANADA'S COMMISSION OF CONSERVATION.

The following reference to the work of the Commission of Conservation appears in the fifth interim report of the Dominions Royal Commission:—

"From an examination of the work carried on by the commission, it would appear that its activities in the domain of lands, minerals, forests, fisheries and waterpowers connect with, and may possibly duplicate, work which is actually done, or which could be more suitably carried on, by the departments of the Federal and Provincial governments charged with the administration and development of these great natural resources, and maintaining for this purpose experienced and expert staffs. The council for industrial and scientific research which has lately been constituted for Canada, on the lines of that in the United Kingdom, will also necessarily devote much of its attention to the tabulation, examination, and testing of the resources of the Dominion in the way of raw materials with a view to their development and utilization in industrial processes.

"It would appear, therefore, that an excellent opportunity is afforded for a co-ordination between the functions of the commission of conservation and other existing departments which would promote both economy and efficiency, and tend to more methodical application of energy.

"We would refer to one point connected with the work of the commission of conservation which deserves special notice. No visitor to the Dominion and to Western Canada in particular, could fail to admire the spacious walks and broad streets of the towns and cities, or to note that these have been laid out not only to meet present needs but with a wide outlook for future development. It is interesting, therefore, to find that the town planning committee of the commission is paying special attention to the details of housing accommodation and conditions, as well as to the principles of scientific town planning, and that its advice is being sought to a greater extent than the present staff can satisfy."

WAR TAXATION ANNOUNCEMENT.

In an official statement issued last week, Sir Thomas White, finance minister, said that the liability to taxation under the Business Profits War Tax Act ceases at the end of the present year and that the proposed increased taxation applies only to the last annual accounting period of the three accounting periods to which the act of last year applies. In other words, the increased taxation will affect only annual accounting periods, which end after December 31st last. For example, if a company's accounting period ends on May 31st of this year, the company will pay the increased tax in respect of its fiscal year commencing June 1st, 1916, and ending May 31st, 1917, and it will not be liable upon its profits earned after May 31st, 1917. The new tax, therefore, cannot apply to new companies about to establish themselves in Canada.

TRAFFIC THROUGH CANADA'S CANALS

Traffic through the canals of Canada in 1916 showed an increase of 8,384,688 tons. The total volume was 23,583,491 tons, though, as pointed out by Mr. J. L. Payne, comptroller of statistics, this tonnage includes duplication. It represents the business through all the canals and the same cargo often passes through two or three separate canal systems. After eliminating all duplication the net tonnage is given as 21,011,905 tons. The distribution of gross traffic in tons was as follows: Sault Ste. Marie, 16,813,649; Welland, 2,544,964; St. Lawrence, 3,368,064; Chambly, 398,977; St. Peter's, 9,629; Murray, 46,680; Ottawa, 237,651; Rideau, 105,430; Trent, 45,000; St. Andrew's, 13,438.

The traffic as analysed is as follows:—

	Tons.
Agricultural products	5,178,806
Animal products	11,342
Manufactured products	834,266
Forest products	1,388,873
Mine products	16,170,204

The total volume of Canadian wheat moved through the canals of Canada and the United States at Sault Ste. Marie in 1916 was 185,003,667 bushels. Of this quantity, 82,807,342 bushels passed through the Canadian canal. Larger accommodation on the American side of the St. Mary's River probably accounts for the preference given that channel.

The growth since 1895 in the volume of Canadian wheat annually carried through the Canadian canal at Sault Ste. Marie is seen from these figures: 1895, 1,087,800 bushels; 1900, 5,573,267 bushels; 1910, 51,774,833 bushels; 1913, 101,066,133 bushels; 1916, 82,807,342 bushels.

The comparison of 1915 and 1916 is as follows:—

Through the	1915. Bushels.	1916. Bushels.
Canadian canal	48,727,911	82,807,342
American canal	121,389,950	102,196,325
Total	170,117,861	185,003,667

Canadian wheat moved in the form of flour must also be brought into the account. The total quantity brought down in 1916 was 3,805,384 barrels, as compared with 2,215,098 barrels in 1915. At 4½ bushels to the barrel, this would represent 17,124,228 bushels of wheat.

The total volume of waterborne wheat in 1916 would thus be made up as follows:—

	Bushels.
Through the Canadian canal	82,807,342
Through the American canal	102,196,325
In the form of flour	17,124,228
Total	202,127,895

The distribution of Canadian wheat, moved through the Canadian and American canals at Sault Ste. Marie from Port Arthur-Fort William in 1916, was as follows:—

To Montreal, 1,233,982 bushels; to Georgian Bay ports, 46,406,749 bushels; to other Canadian ports, 28,029,847 bushels; to Buffalo, 106,349,943 bushels; total, 182,020,521 bushels.

To account for all the Canadian wheat shipped eastward by water in 1916 there must be added the quantity passed through Duluth in bond. The complete statement would therefore be as follows:—

From Port Arthur-Fort William and Duluth, to Montreal, 1,686,482 bushels; to Georgian Bay ports, 48,007,361 bushels; to other Canadian ports, 28,029,847 bushels; to Buffalo, 107,279,977 bushels; total, 185,003,667 bushels.

"The people of British Columbia should realize the importance of turning out vessels and steamers as fast as they can be completed," said Mr. J. J. Coughlan, of the firm of John Coughlan and Sons, in a recent interview regarding the shipbuilding programme on the Pacific Coast. "Our first boat," he said, "is well under way and will take to the water in November at the present rate of construction. We are laying the keel for the second vessel at the present time, and next week we will lay the keel for the third vessel. The second vessel will be launched in December and the third in February of next year. We are now contemplating clearing away space for a fourth keel."

SHIPBUILDERS BUSY IN NOVA SCOTIA

We have developed Nova Scotia's great coal industry. Following that its iron industry has attained international importance. So once again the opportunity presents itself of playing a part in transporting the commerce of the world. Added to this a great emergency confronts the empire. "Ships! Ships! Ships!" is the cry. This is the editorial comment in a timely shipbuilding number of the Halifax Morning Chronicle, which furnishes data regarding the shipbuilding industry of that province.

On the Atlantic Coast there are 51 wooden vessels of a total tonnage of 16,316 under construction, of which 46 are being built in Nova Scotia. Every shipyard in the province is being worked to capacity. At Lunenburg, La Havre, Liverpool and Shelburne, attention is being mostly devoted to fishing and coasting vessels. On the French Shore, St. Mary's Bay, at Annapolis, at Parrsboro, Fox River, Port Greville, Spencer's Island, Advocate Harbor, at Hantsport and Noel, and other points, there are under construction tern schooners for the deep sea trade, varying in size from 200 to 500 tons, and there are tern schooners under construction at Liverpool and Shelburne.

At Meteghan, St. Mary's Bay, a tern schooner has been started. At Little Brook one is almost completed. There is one soon to be launched at Grosses Coques, where two more are to be started, and there are two at Belliveau's Cove. At Parrsboro there is under construction a schooner of about 600 tons, at Fox River a schooner of about 460 tons, at Port Greville a schooner of about 350 tons and another of about 200 tons. At Spencer's Island a 430-ton schooner, at Advocate Harbor a 460-ton schooner, at Hantsport a 350-ton schooner, and several large schooners at Annapolis.

The Nova Scotia Steel and Coal Company's first steel vessel which is 260 ft. in length, and has a carrying capacity of 1,900 tons is nearing completion at the Trenton shipyards. The keel has been laid for a second boat which is about 260 ft. overall, and has a deadweight capacity of about 2,400 tons, propelled by triple expansion engines. These engines will be built complete at this plant. The steam will be furnished by two Scotch boilers 11 ft. diameter and 10 ft. 9 in. long, with a working pressure of 185 lbs. per square inch. The boilers are being built by the John Inglis Company, Limited, Toronto.

Mr. Wallace Downey, a Nova Scotian, of the Downey Shipbuilding Corporation, New York, says that unnecessary costs in shipbuilding and ship operation, resulting from endless variety, is probably about 20 per cent. in excess of what the building and operating costs of the world's shipping would be if types and sizes were standardized and specialized for certain trades and uses. Twenty per cent. upon the cost of the world's shipbuilding and operation would, of course, aggregate hundreds of millions annually.

This is an unnecessary overhead charge on water transportation. He believes the cost of shipbuilding can be reduced at least 20 per cent. by standardization, and I believe the cost of operating ships can be reduced from 10 to 20 per cent. by standardization and specialization.

BURNS CEMENT-GUN CONSTRUCTION CO.

L. P. Burns, of Toronto, formerly a well-known railroad contractor, has organized the Burns Cement-Gun Construction Co., with head office in the Bank of Hamilton Building, Toronto. The company will specialize on Gunite construction.

They are now completing self-contained outfits mounted on motor trucks, the engine and compressor being arranged on a trailer, with the gun and materials on the truck itself. These portable outfits will have great facility in reaching work in any portion of Ontario.

Garages and other building work will be handled, but special attention will be given to the construction of concrete walls, floors, etc., for reservoirs, filtration plants, sewage disposal plants and other engineering work such as the coating of steel penstocks, tanks, etc. The company expects to develop as a specialty the lining of steel ships with Gunite instead of hand-placed cement mortar.

"HYDRO" ACQUIRES ONTARIO POWER CO.

Sir Adam Beck announced last week that the Hydro-Electric Power Commission of Ontario had acquired the assets and rights of the Ontario Power Co. The commission pays eight million dollars in its own debentures for the ten million dollars outstanding stock of the company, and assumes the company's bond liability of $14,669,000. The company is to receive the current assets and assume the current liabilities.

The deal involves no cash outlay by the province. The company's book valuation is $20,000,694, and the total revenue for 1916 from the sale of power was $2,396,277. The net income for the year was $1,501,353. The bond interest was $767,118, so that the net earnings of the company were $734,235. F. A. Gaby, chief engineer of the commission, estimates an annual surplus of $201,000 after paying the interest on the Hydro bonds, but without allowing for depreciation.

A portion or all of the water now used by the Ontario Power Co. will probably be diverted through Chippewa Creek and used in connection with the Queenston Heights development of the Hydro Commission. The Hydro's new plant will be capable of developing 27 electrical h.p. per second foot, whereas only 16 h.p. is developed by the Ontario Power Co. at the present time, and from 12 to 13 h.p. by the Canadian, Niagara and Electric Development companies. The Hydro Commission will have a 315 ft. gross head and a net head of 303 ft., and Hydro officials state that their calculations are conservatively estimated on a basis of 84 per cent. turbine efficiency and 93 per cent. generator efficiency.

The ultimate capacity of the Queenston plant is expected to be about one million horse-power, and to develop this Sir Adam Beck will have to buy out the two remaining Canadian power companies, so as to get the whole of the Canadian allotment of 36,000 cubic ft. per second, or else the Canadian government will have to induce the United States to make an agreement whereby Canada will be allowed to divert more water from the falls. There has been considerable agitation in the United States for a further diversion on that side of the boundary, and it is probable that within the next four or five years a new treaty will be entered into, permitting greater diversion both in the United States and Canada.

The Hydro Commission is spending fifteen million dollars on the Chippewa scheme, which will no doubt absorb the Ontario Power Co.'s system in the course of time. It is figured that the Ontario Power Co.'s plant will pay for itself in fifteen years by the "scrapping" process; that is, by applying to surplus the revenue ordinarily apportioned to depreciation.

Sir Adam Beck considers the Ontario Power Co. the most efficient power concern on the Canadian side of the Niagara River, as this plant is said to suffer less interruption from ice troubles than the other plants. Moreover, it has a tranchise capacity of 180,000 h.p., and by means of an additional conduit (and enlargement of the franchise) its capacity can be increased to 240,000 h.p. The Electrical Development Co.'s plant has a capacity of 125,000 h.p., and that of the Canadian Niagara Co. has 100,000 h.p. capacity.

Of the 36,000 second feet permissible diversion from the falls, the Ontario Power Co. is entitled to 11,180, the Canadian Niagara Co. to 8,820, and the Electrical Development Co. to 9,390, leaving a surplus of 6,610 which will be used for the Chippewa scheme. By using the Ontario Power Co.'s water, the Chippewa scheme will now have a supply of 17,790 second feet, by means of which it is expected to develop at least 480,000 h.p.

In connection with the transfer of the property, Sir Adam Beck succeeded in modifying the company's contract with the Niagara, Lockwood and Ontario Co., by means of which the Ontario Power Co. was bound to deliver about 60,000 h.p. until the year 2010. An arrangement has been made to terminate this contract in 1950, so that 60,000 h.p. additional will be available for Canadian use sixty years sooner than would have otherwise been the case, assuming that the export of power would not have been prohibited anyway by the Dominion Government before that time.

Construction work on the Chippewa Creek scheme is going ahead as fast as the equipment is arriving on the ground. One steam shovel and a gang of one hundred men are now at work under Superintendent Angel.

The Hydro Commission is now selling about 146,000 h.p. in the Niagara District alone, of which 100,000 h.p., is being secured from the Ontario Power Co., and 46,000 h.p. from the Canadian Niagara Co. It is expected that by November 1st, 1917, the requirements of the Niagara district will have reached 190,000 h.p. This is exclusive of the 60,000 h.p. now being sold to Canadian customers by the Ontario Power Company. Immediately upon taking over the latter concern, the Hydro's Niagara load really became 200,000 h.p.

These figures are exclusive of the requirements in the territory covered by the Hydro's other districts, viz., Severn, Wasdell's, St. Lawrence, Eugenia, Ottawa, Port Arthur, Muskoka, Central, and Northern.

Twenty cities, thirty-four towns, one hundred and twenty villages and seven townships of Ontario are embraced in the Hydro-Electric System. The System represents a public expenditure of $60,350,000, not including the $15,000,000 for the Chippewa scheme, and not including the Ontario Power deal.

MONTREAL AQUEDUCT REPORT.

(Continued from page 483.)

Under ordinary conditions, and with the figures now before us, we would have no hesitation in recommending the adoption of Scheme 2, with provision for boulevards, as its cost of operation per h.p. per year is the lowest. But under the circumstances which have allowed of the contractor being able to proffer a claim of $1,469,338.17 on a contract of $3,012,562, on which work to the amount of $1,148,731.38 had been completed at the end of 1916, the question is different. We must also take into account the fact that the contractor has to be reckoned with for any changes or additions to the present plan. We would, therefore, recommend:—

1st. That the south wall of the aqueduct be at once extended to the rock section and that the west earth section be completed with paving where needed, as this should be done for all schemes.

2nd. That no work be done on the rock section nor on the east earth section until the final scheme is decided upon. This also applies to the tailrace.

3rd. That you immediately ask the several companies furnishing electric power in the city for firm bids of power. Carefully worked out specifications should be furnished to the power companies setting forth the exact conditions of the service required.

Prices should be, at the same time, obtained from the contractor for all changes, and additions to the present contract.

As soon as this is done (and it could be done in a couple of weeks) you shall be able to come to a decision with full knowledge of the costs of operation of all schemes.

As all our figures will be in the hands of your chief engineer, he will be able to place before you the exact cost of each scheme.

In the meantime, studies should be started and designs made for the proposed electric motor-driven pumping station. This station should be designed to pump the output of the proposed new filter plant, which is to be 100,000,000 Imperial gallons per day. Provision should also be made for future extensions. The equipment of this station will be the same whether you generate your own electric power, or buy it. The plans for the steam standby station should also be put in hand. We have suggested that the new pumping plant be located on the south side of the aqueduct near the filters. This should provide a most convenient location for all piping connections. It also facilitates the connection of the steam standby to the heating system that is proposed for the filters.

No addition or alterations to the present steam pumping plant should be made.

The plans for the hydro-electric station may be delayed until you have to come to a decision regarding the source of power.

We would also recommend:—

4th. That the lands required be secured at once, so as to prevent further delays to the work.

5th. That the addition to the filtration works at a cost of $900,000, as estimated on page 85 in the annual report of 1915, be proceeded with.

Mr. Thomas J. Dillon has been appointed general manager of Canada Foundries and Forgings, Limited. Mr. Dillon has had jurisdiction over the western plants at Welland, Ont., the Canada Forgings and Billings and Spencer. This now extends to the James Smart Manufacturing plant at Brockville. Mr. Dillon is also a director of the company.

Editorials

THE RAILWAY PROBLEM.

What is the government doing in regard to the railway problem? The two reports presented by the Railway Inquiry Commission were brought down some weeks ago, but apparently no steps have yet been taken to relieve the situation. Both the majority and the minority reports agree that something must be done. Both suggest radical changes; and the commissioners are unanimous in stating that more equipment is needed.

It is sincerely to be hoped that the freight situation of last winter will not be duplicated—or worse—this coming winter. More freight cars, more coal cars and more engines appear to be an immediate requirement, regardless of what is done or left undone in reorganization of the Grand Trunk and Canadian Northern.

When the railroad report was first made, parliament was urged to give sufficient consideration to it, that the right course might be taken at this juncture.

There is no doubt that to make further mistakes in the railroad policy would prove extremely costly to the country. The greatest caution should be exercised before deciding to amalgamate under one management 25,000 miles of railway lines which, in respect of mileage and territory served, have no parallel; to acquire the control of their stocks; to operate the roads; to assume responsibility for the interest on their debts,—and all this during a period of world-wide unsettlement of business conditions.

But careful consideration by parliament does not mean pigeon-holing by the government. Thorough investigation and extensive parliamentary debate are necessary to the settlement of this question. If the proper time is to be given to the subject in parliament, the government should introduce a formal measure, which would precipitate the debate, soon enough for some definite and thorough-going action to be taken before another winter catches any of our railroads without the necessary equipment to meet the conditions experienced in this climate.

MR. ACWORTH'S VIEWS.

Members of parliament will no doubt attach the greatest importance to the fact that Mr. Acworth's views have coincided with those of Sir Henry Drayton. Prior to Mr. Acworth's appointment on the Canadian Railway Inquiry Commission, he said:—

"A careful study of the evidence has convinced me that in the long run state control ends in keeping down the best to the level of the worst, and that, taking them all for all, the private railway companies of England and the United States have served the public better than the government railways of the Continent, or of our Australian colonies, and, which is still more to the point, are likely to serve it better in the future."

Yet holding that opinion, Mr. Acworth joined Sir Henry Drayton in a proposal practically to nationalize the railways and to operate them by a permanent commission.

Sir Henry Drayton, in his recent Toronto address, drew attention to the fact that Mr. Acworth is familiar with company management and finance, being a director of the Underground Railway of London, which controls the greater part of the transportation facilities, both street and underground, including the omnibuses, in and around the metropolis. He is a recognized authority on railway economics, he has written leading text books on the subject, and in the opinion of the practical railroad managers of America his knowledge and standing is such that he was engaged by them to give evidence last month in their behalf before the Congressional Committee on Transportation at Washington, in regard to the evils of political railway management.

The politicians at Ottawa may not like the references to politics and political management in either the majority or minority reports of the commission. There is sure to be extensive debate upon the whole subject, and the earlier the debate is started, the sooner a decision will be reached; and the sooner the situation is taken in hand and a solution found for it, the better will it be for all classes of the public, including even the owners and operators of the railroads themselves.

THE TYE AND TAIT REPORTS.

Before the appearance of the report of the Railway Inquiry Commission, the problem had been unofficially discussed in two pamphlets, both of which were published in full in *The Canadian Engineer* at the time they were issued. The author of one was Mr. W. F. Tye, for many years chief engineer of the Canadian Pacific Railway; the author of the second, Sir Thos. Tait, at one time a prominent administrative officer of the C.P.R., and for seven years chairman of the Victorian (Australian) Railway Commission, and since 1911 president of the Fredericton and Grand Lake Railway & Coal Co., which built in New Brunswick a railway that has been leased to the Canadian Pacific.

The influence of both of these private reports on the majority report of the Railway Inquiry Commission is marked. Many of the suggestions made have obviously been incorporated in the report of the commission.

This influence, brought to bear by private reports from two engineers, and reflected in the report made by a lawyer and a financial economist, is further evidence that commissions dealing with engineering subjects should include engineers. In all questions dealing with efficiency or management, engineers—by virtue of their training—can bring valuable help. When these questions deal with subjects so directly in the engineering field as transportation, it should be a first corollary of the government that engineers should be included in the make-up of the commissions.

Mr. Tye's work and Sir Thos. Tait's work should not be forgotten. We have no desire to pile cabinet timber at Sir Robert Borden's doorstep, but may we say that if the majority report of the Railway Inquiry Commission be adopted, the government will have no difficulty in finding at least two of the three able railway commissioners who will be needed on the Board of Trustees?

PERSONALS.

GRAHAM MIRDRIE BELL, Department of Railways, Ottawa, was included among those mentioned in the King's birthday honors. He was gazetted a Companion of the Order of St. Michael and St. George.

R. T. BELL, formerly division engineer on the National Transcontinental Railway, and latterly superintendent of the Toronto-Hamilton Highway and superintendent of road construction at Camp Borden, has received a commission as captain of the 23rd Draft Reinforcements for Canadian Railroad Troops. Capt. Bell has opened a recruiting office at 16 Temperance Street, Toronto, and he is permitted to recruit in the district from Port Arthur to Cochrane, and also in the city of Toronto.

H. VICTOR BRAYLEY, A.M.Can.Soc.C.E., has resumed his connection with Gunn, Richards, Limited, of Montreal and New York, and will be joint Canadian manager with T. Max Fyshe, A.M.Can.Soc.C.E. Mr. Brayley resigned from Gunn, Richards, Limited, a couple years ago in order to carry out some special production engineering work for Sir Mortimer B. Davis.

W. R. BURGE, who recently resigned as Toronto manager of the Jenckes Machine Co., is now a member of the Ontario sales organization of the Canadian Allis-Chalmers, Limited, Toronto.

GEORGE J. BURY, Montreal, vice-president of the C.P.R., was among the Canadians included in the list of King's birthday honors, having been made a knight.

P. F. CAVERHILL, chief provincial forester of New Brunswick, has resigned and will return to British Columbia.

ERNEST A. CLEVELAND, M.Can.Soc.C.E., DONALD CAMERON, M.Can.Soc.C.E., and STUART S. McDIARMID, B.Sc., who have conducted a consulting engineering office at Vancouver for several years under the firm name of Cleveland & Cameron, have dissolved partnership. Mr. Cleveland is continuing business at the same office, 1001 Rogers Building; Mr. Cameron has entered practice on his own account in the same building; and Mr. McDiarmid has a commission in an overseas draft of the Forestry Battalion.

WILLIAM H. CONNELL, for about five years chief of the Bureau of Highways and Street Cleaning of the Department of Public Works of Philadelphia, Pa., has tendered his resignation, effective May 31. He is to become connected with the firm of Day & Zimmerman, 611 Chestnut Street, Philadelphia, as engineering executive.

C. A. HAYES has been appointed general manager of the Government Railways east of the St. Lawrence River, with headquarters at Moncton, N.B., in succession to F. E. Gutelius, and E. P. BRADY has been appointed general manager of Government Railways west of the St. Lawrence, with headquarters at Cochrane, Ont. W. A. COWAN has been appointed assistant to Mr. Brady.

Major W. G. MACKENDRICK, president of the Warren Bituminous Paving Co. of Ontario, Limited, Toronto, who has been in France for about a year and a half building roads, first for the Canadian Corps and then as deputy assistant director of roads and in charge of all roads in the Fifth Army, has been promoted to be assistant director of roads and given the rank of lieutenant-colonel.

JAMES O. MEADOWS, A.M.Can.Soc.C.E., who was joint author, with Mr. Frank H. Pitcher, of the article on the Montreal Water & Power Co.'s chlorine cell installation, published last week in *The Canadian Engineer*, was incorrectly described in connection with that article as being the chief chemist of the Montreal Water & Power Co. Mr. Meadows is the company's sanitary engineer.

Lieut.-Col. C. H. MITCHELL, M.Can.Soc.C.E., member of the consulting engineering firm of C. H. and P. H. Mitchell, Toronto, was among those honored by the King in the birthday list. He was made a Companion of the Order of St. Michael and St. George.

WILLIAM RODGER, who has been chief draughtsman with the Jenckes Machine Co., of Sherbrooke, Que., for the past eighteen months, has accepted a position as construction engineer with Fraser, Brace & Co., of Montreal, contracting engineers.

OBITUARIES

ANTOINE BALZOLA, president and secretary-treasurer of the Niagara-Spanish Aerial Car Tramway over the Whirlpool, died of heart failure at Niagara Falls, Ont. Mr. Balzola's home was in Spain. He was the chief promoter of the novel enterprise at the Whirlpool.

Capt. W. J. EAGAN, of Cobden, Ont., was killed in action about ten days ago. Capt. Eagan was a member of the firm of Shea & Eagan, railway contractors, who executed contracts on the National Transcontinental and Canadian Northern Railroads, as well as in connection with the double-tracking of the C.P.R.

THOMAS KENNEDY, who for more than fifty years was prominently identified with Messrs. Glenfield & Kennedy, of Kilmarnock, Scotland, died April 20th in his 79th year. For a long period Mr. Kennedy was managing director of the company but had lived in retirement for the past four years. Previous to entering the firm of Glenfield & Kennedy he followed the sea as a marine engineer and assisted in the laying of the first Atlantic cable. Much of the success which has attended the Glenfield & Kennedy Company is due in large measure to his exceptional skill, his rare organizing powers and his devotion to duty. Mr. Kennedy was a member of the Institution of Mechanical Engineers and the Institute of Engineers and Shipbuilders.

ADOLPHE RODRIGUE PINSONAULT, a well-known railway engineer, of Montreal, died May 24th in his 69th year. Mr. Pinsonault was engineer of the Intercolonial Railway between River du Loup and Truro, N.S. Later he was attached to the engineering staff which laid out the line of the C.P.R. around the north shore of Lake Superior.

MALCOLM J. ROBINSON, formerly minister of public works for Saskatchewan, died suddenly on May 26th in the Queen's Hotel, Toronto. Mr. Robinson graduated from the School of Practical Science, Toronto, in 1895, and had spent practically all his life since that time in Western Canada.

G. A. STEWART, who died recently at Victoria, B.C., assisted in the construction of the first railway built in Canada, and was later assistant engineer of the Northern Railway from 1852 to 1854. He practised his profession at Port Hope from then until 1865, and was chief engineer of the Midland Railway from 1868 to 1877. In 1886, Mr. Stewart was appointed to make topographical surveys of the Rocky Mountain National Park, Banff, Alberta, and was in charge there for eleven years.

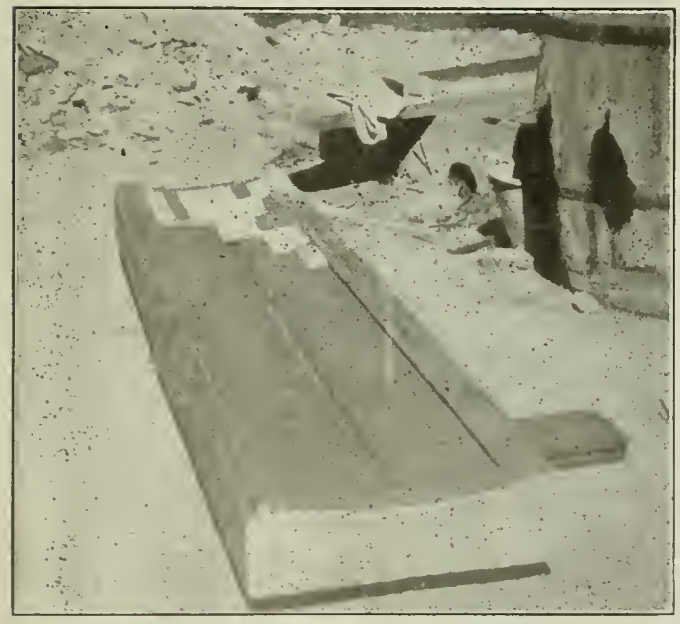
The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Activated Sludge Experimental Work at Milwaukee

Influence of Low Temperatures Not Detrimental—Sludge Can be Converted into a Profitable Marketable Fertilizer—Determination of Best Methods of Diffusing Air Throughout the Sewage—Third Annual Report of Milwaukee Sewage Commission.

THE following extracts, taken from the third annual report of the Milwaukee (Wis.) Sewage Commission, which commission has made an unusually valuable contribution to the commercializing of the activated sludge process of sewage disposal, are of timely interest. The report describes the changes which have been found necessary, refers to the erroneous assumptions made in



Showing concrete retainer for wood block diffusers. A few wood blocks shown in place. Blocks ½" thick and from 2½" to 4" square.

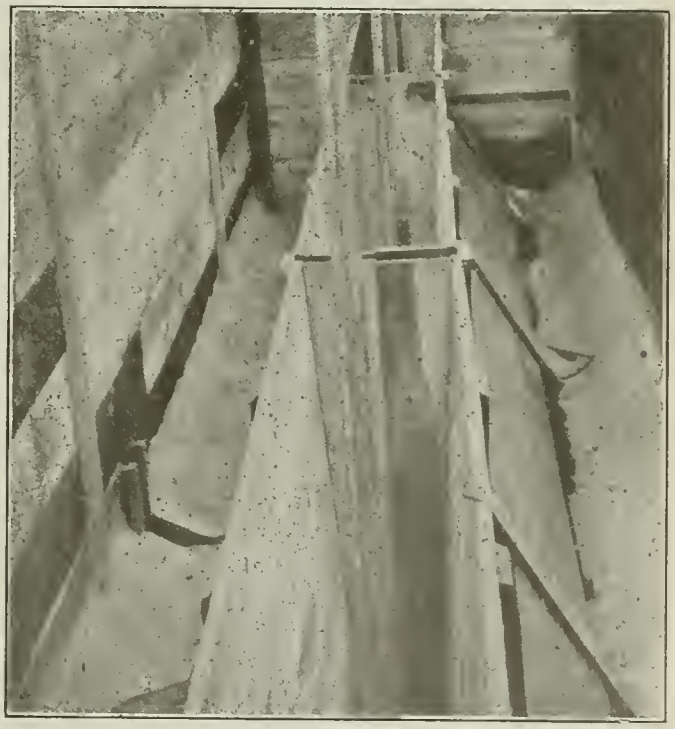
the original design of the plant and what was done to overcome the difficulties that confronted those in charge of the experiments. The report continues as follows:—

The permanent plant was designed, from the information then available, to treat 1,600,000 gallons per 24 hours with a four-hour period of detention and about 2,000,000 gallons with a three-hour period. The sedimentation tank was designed to provide for the maximum quantity treated on the basis of 22 minutes sedimentation period.

It was soon discovered that several serious errors had been made in our assumptions which prevented the plant from satisfactorily treating the volume of sewage for which it had been designed. The most prominent of these were that the conduits which carried the mixed liquor and activated sludge from one set of tanks to another became partially stopped up with the sludge which settled to the bottom almost as soon as the mixture entered the conduit. This sludge became septic and the dissolved oxygen in the liquor in tank No. 3, for instance, was less than that in No. 2, it having been taken up by the septic sludge contained in the conduit connecting the two tanks.

This, of course, pointed to the necessity of eliminating in our final plant all connecting conduits designed to carry the mixture of sludge and sewage.

The building-up of the air pressure in the tanks from 5½ pounds to nearly 8 pounds, with a consequent loss of air necessary for oxidation led us to examine the filtros plates in the bottom of the tanks. We found these largely stopped up with a mixture of oil and fine particles of dust. This determined the absolute necessity of providing an air blower of a type which would certainly exclude all oil from the air discharge pipe, and the thorough washing of all air passing to the filtros plates. The excelsior filler which we had provided for this service having proven inefficient, other methods had to be devised.



Showing baffles in Nordell Aerating Tank. Baffles in form of chimneys with flared sides and curved bottom, standing about 3" above wood block diffusers. Liquid contents of tank forced upward through chimneys by air pressure and passes back to diffusers on the outside of chimneys, making complete circulation and high velocity when passing over surface of diffusers.

We also determined from a careful testing of the porosity of the plates before, after and during service that a plate of fine porosity was less efficient than a coarser one. That is, instead of a plate which would pass from 2 to 4 cubic feet of air per minute per square

foot under a 2-inch water pressure, one which would pass from 10 to 12 cubic feet of air per minute created less friction, maintained more uniform diffusion, and was less liable to stoppage.

The sedimentation tank was built 28 ft. 4 ins. in diameter to a depth of 3 feet below water level, and 4 feet in diameter at a depth of 11 ft. 6 ins. below water level. The bottom being built of a slope about 1 to 1. The 4-foot diameter section extended to 34 feet below water level. A 12-inch diameter pipe extended from a few feet above the surface of the water to 9 inches above the bottom of the tank. An air pipe was built inside this 12-inch pipe through which the air is delivered to raise the sludge, accumulating in the bottom of the tank, through the 12-inch pipe to the top and deliver it either to the raw sewage or to the aerating sludge tanks.

The operation of this tank soon proved several facts: That a slope of 1 to 1 was not sufficient to keep the sludge moving towards the central chamber; that it would remain on this slope and become septic reducing the dissolved oxygen in the effluent; that the velocity through the tank was too great and double the detention period was necessary; that there was a distinct relation between the density of the sludge raised from the bottom of the tank and the velocity by which it flowed. That is, a high velocity would raise a wetter sludge than a low velocity of flow. Thus the 12-inch sludge riser pipe should be reduced to 6 inches; and moreover, the sludge should be taken downward, rather than upward, from the apex of the sludge chamber.

The best we could do with the plant as originally designed, was to put through about 750,000 gallons of coarse screened sewage per day and produce a clear stable effluent, reducing the bacteria about 95%, suspended matter 97%, and oxygen consumed about 80%.

Recognizing that the greatest defect was in the sedimentation tank, we improvised No. 11 tank, which had been designed as a sludge aerating and storage tank, into a sedimentation tank. This tank was 30 feet in diameter with an effective depth of about 9 feet. It was divided by a spiral wall into a continuous compartment about 6 feet wide and about 90 feet long.

Reference to Mr. Copeland's report will explain in detail the changes made in turning this tank into a sedimentation tank and need not be repeated here, but the facts observed during the period this tank was operated as a sedimentation tank were, that we obtained a satisfactory effluent at the rate of 750,000 gallons per day with an effective head equal to nearly one-fourth of the head in the main sedimentation tank and with about one-half of the cubical contents; that we satisfactorily treated 1,500,000 gallons of raw sewage through the aerating tanks and were in a fair way to increase this rate when our big pump went out of service.

In other words, the greatest defect of the plant was in the sedimentation end and not in the aerating end, and that the main problem which now confronts us is to design a sedimentation tank which will produce an uniform horizontal velocity of 3 feet per minute or a vertical velocity of 8 inches per minute and insure the complete removal continuously of precipitated sludge as rapidly as formed.

During the shutdown of the plant we decided, after thoroughly examining the condition of the filtros plates, to remove them, substitute new ones over the entire plant and start anew. The General Filtration Company magnanimously consented to co-operate with us and furnish us without cost all the plates we needed and to furnish the best it could produce.

The Connersville Blower Company revised the bearings of the two blowers it had furnished so that all oil would be eliminated from the inside of the blower casing, and we set up an air washer furnished by the Spray Engineering Company to wash and dry the air before it reached the blower. This new installation has just been completed and we hope within the next few months to obtain much more satisfactory results from our plant than heretofore.

Sludge Disposal.—To record all the details of the experiments we have made during the year in investigating the sludge disposal problem, would fill many pages. Everything which held any promise of success has been tried so far as time and labor have been available, to the end that we have determined primarily that activated sludge can be successfully dewatered and reduced to a fertilizer base at an expense less than its value, and that there is ample available market for all we can produce.

Early in the year H. R. Worthington furnished, at its own expense, a Berrigan Press, 6 ft. x 9 ft. in size. Mr. Berrigan, the designer, and Mr. Towle, the engineer for Worthington, carried on a continuous line of experiments with this press for several months, after which we operated it ourselves until the plant shut down.

Starting with the production of less than 100 pounds of pressed cake per pressing, the press was developed to a point where it produced about 1,800 pounds per pressing, containing 75% moisture.

The operation of the press was reversed so that the filter bags could be filled and emptied much more rapidly, and various types of bags were tried out. Investigations were made of the porosity of the bags under the existing conditions, their tendency to shrink, and the necessity for cleaning and repair. Careful estimates were made, so far as information was available, of the cost of pressing, including the cost and upkeep of the filter bags.

The approximate cost, based upon treating 100 million gallons per day, excluding overhead charges on building, is as follows:—

Overhead charges—10% of cost	$1.21
Labor—8 hours—3 shifts	1.36
Cleaning and upkeep of bags	.64
Power	.09
Contingencies	.16
Total cost, per dry ton	$3.46

From our investigations one-half a ton of dry sludge is produced from one million gallons of sewage treated, the approximate cost of pressing sludge would be $1.73 per million gallons of sewage.

From the information available at the present time, the approximate cost of drying and grinding the sludge, exclusive of overhead charges for building, are as follows:—

Overhead charges—15% of cost	$0.39
Labor—8 hours—3 shifts	.73
Fuel—one cent per 82,000 B.t.u.	1.10
Power—one cent per kw. hr.	.52
Grinding	.25
Contingencies	.18
Total cost of drying, per dry ton.	$3.17

On the basis of one million gallons producing one-half ton of dry sludge, the approximate cost of drying will be $1.59 per million gallons of sewage treated, or $3.32 per million gallons of sewage treated for reducing the sludge produced to a fertilizer basis.

The value of this sludge as a fertilizer is based upon the quick availability of its contained nitrogen as NH_3. From growing experiments being carried out at the University of Illinois during the last 18 months, the availability of this nitrogen has been proven beyond any doubt and its value is equal to the same quantity of NH_3 contained in any of the high-grade fertilizers.

It would appear appropriate, after over two years of continuous experimental work upon sewage disposal, to present at this time a brief résumé of the conclusions reached. In forming these conclusions there are certain determining conditions connected with the Milwaukee situation, which are not common to all large municipalities, to-wit:—

The natural drainage of the present city and the area embraced within the anticipated limits of 1950 converge into one outlet, the harbor entrance.

The public water supply is secured from Lake Michigan in 50 feet depth of water at a point located about 3½ miles from the harbor entrance. This condition requires a high standard effluent of uniform quality to be produced from a sewage treatment plant.

There is no constant current in any one direction in the lake. The velocity and direction are largely due to meteorological conditions.

The only logical site for a sewage disposal plant is on or near the lake shore and the only available ground is Jones Island.

The natural island has far too small an area to locate a sewage disposal plant thereupon, and such plant must be built upon ground made out into the lake.

There is no low ground either in the city or its proximity suitable to the disposition of sludge; in fact, low ground is so scarce that those who are required to dispose of waste materials pay for the privilege of filling in the low ground. Sludge could not be used to make up land into the lake, as it would cause a nuisance which would not be tolerated by the owners of the lake front and might pollute the bathing beaches. It is considered inimical to public policy and to the future of our harbor to deposit sewage sludge in the lake. It therefore appears mandatory to either incinerate the sludge or reduce it to and dispose of it as a fertilizer.

Locating the disposal plant within the city limits, as appears necessary, prohibits a sewage treatment process which produces objectionable odors or flies.

Chemical precipitation removed the solids in suspension to a satisfactory degree, but the effluent produced did not reach the stability requirements. The sludge produced was enormous and its value was not sufficient to warrant the cost necessary to reduce it to a fertilizer. Its incineration would cost between $12 and $14 per million gallons of sewage treated.

Treatment by colloidar slate tanks gave a satisfactory effluent most of the time, but produced enormous quantities of sludge with low value as a fertilizer. The first cost of such a plant would be prohibitory.

Fine screening, considered as a single process, would neither remove sufficient suspended matter to meet the requirements nor improve the stability of the sewage.

Electrolysis was both offensive and uncertain. It had to be augmented with lime treatment and produced large quantities of sludge which was unprofitable to reduce to a fertilizer. From our experiments carried out with this process, the operating charges would be prohibitory.

Sedimentation by Imhoff tanks reduced the suspended matters about 50%, but produced a highly putrescible effluent. To satisfactorily sterilize this effluent required approximately 9 parts of chlorine, costing about $5.30 per million gallons. The sludge produced was not of sufficient value to warrant its reduction to a fertilizer, and to incinerate it would cost approximately $5 per million gallons of sewage treated.

Imhoff tank and sprinkling filters followed by final sedimentation produced a satisfactory effluent capable of being discharged into the lake without endangering the water supply. This treatment left us with the sludge to dispose of by incineration, cut out the sterilization, produced objectionable odors and flies, and required a prohibitory area of ground (nearly 100 acres) to be made up in the lake. The overhead charges for first cost of plant, under the existing conditions, add nearly $9 per million gallons to the cost of treatment by this process.

Activated sludge, if properly designed, built and operated, produces a clear, non-putrescible effluent, with a reduction of at least 95% bacteria and 98% suspended matters, and a sludge of sufficient value to warrant its reduction to a fertilizer. Its operation is odorless and free from flies and it occupies a minimum area of ground.

On the other hand, it requires constant and expert supervision for its successful operation and large operating cost for air and sludge disposal. Its cost, including all overhead, operating and sludge disposal, is estimated to be from $12 to $15 per million gallons, from which must be deducted such returns as may be obtained from the sale of the sludge, which has been estimated in preceding pages to be from $5 to $6 per million gallons, or a net cost of from $7 to $10 per million gallons of sewage treated.

Of all the processes experimented with the activated sludge appears to be the only one which fits the existing conditions in Milwaukee.

The maximum volume of air required to produce a stable effluent from the Menomonee Valley sewage, from which 95% of bacteria and 98% of suspended solids have been removed, is 2 cubic feet per gallon of sewage, based on 10 feet effective head of sewage in the aerating tanks.

The maximum aerating period for both sewage and activated sludge is 4 hours.

The percentage of activated sludge in contact with the sewage may range from 15 to 25, without materially affecting results.

The sedimentation period required is from 40 to 50 minutes. The maximum horizontal velocity is 3 feet per minute and the vertical velocity about 8 inches per minute. Uniform velocities must be maintained as far as possible.

The slopes for successfully removing sludge from the sedimentation tanks should be from 1 to 2, to 1 to 3, and it is preferable to remove the sludge through a down pipe built in the bottom of the sedimentation tank.

Breaking up the air in small bubbles increases the oxygen absorbed by the sewage in the aerating tanks, but sufficient air must be diffused through the sewage to rapidly disturb its entire volume and to maintain the solids in suspension. Baffles properly placed undoubtedly increase the efficiency of the tank.

Filtros plates are a satisfactory media for air diffusion. To maintain their efficiency they should be carefully made and placed, fairly uniform in porosity and all oil and dust should be excluded from the air passing to and through the plates.

Wood plates give smaller bubbles than filtros plates at less loss in pressure, but insufficient experiments have been carried out to warrant their adoption.

The sewage can be clarified in from one to one and one-half hours' aeration in the presence of well activated

sludge, by using from ½ to 1 cubic foot of air per gallon in a 10-foot depth of tank, but the activity of the sludge cannot be maintained without additional aeration.

If clarification alone was required, aerating the sludge three hours and the sewage one hour would produce the desired results.

Maintaining a sludge blanket near the surface of the sedimentation tank filters the floating matters from the liquor and produces a sparkling, clear effluent, but this blanket is difficult to maintain, as it is quickly affected by temperature changes, variations of flow through and sludge from tank.

The aerating tanks can take care of storm water flow when designed to provide for average dry-weather flow by increasing the volume of air and the activated sludge, but extra sedimentation area must be provided for storm flow if standard effluent is to be maintained.

Conduits cannot be used to carry a mixture of sewage and activated sludge, because the sludge settles too quickly, even though velocities of 2 feet per second are maintained.

The activated sludge precipitated in the sedimentation tanks contains about 99% water. This may be reduced by subsequent settlement for from 1 to 3 hours to 96%.

Overaeration of sludge reduces its volume and its tendency to flock, and decreases its specific gravity.

Sludge can be dewatered satisfactorily from 96% to 75% moisture by either a plate press or pressure press without the addition of lime or other base. The minimum cost for this process is still undetermined.

The filter bags used in the presses must be cleaned frequently to maintain efficiency. This can be done by soaking in a bath of dilute caustic soda and hot water.

Sludge, after pressing, can be stored in a building without creating offensive odors more than 50 feet away, and can be easily handled.

The dewatering of sludge from 75% to 10% moisture can be satisfactorily accomplished by either the indirect steam or direct heat dryers, without appreciable loss of ammonia. The minimum cost for this operation is still undetermined.

Milwaukee sludge, after drying, contains from 4.5 to 5% of ammonia as a fertilizer. There is ample market for such a production when reduced to the proper form.

Estimating four hours' aeration of sewage and two hours subsequent settlement of sludge, eight million gallons of sewage can be treated upon one acre of ground.

Although there are many other conclusions of minor importance which have been reached from the experiments made, those enumerated above are of the most importance in determining the design of the large plant.

A $2,500,000 coal pier that can load 7,000 tons of coal an hour has been opened by the Baltimore & Ohio Railroad at Curtis Bay, near Baltimore. The structure is of unusual interest because of its capacity, which is claimed to be the largest of any coal pier yet constructed, and because it handles coal by belt conveyors instead of by gravity. This arrangement greatly reduces the breakage by making three feet the maximum fall for coal from the time it leaves the car until it reaches the ship. At the land end of the pier, which is of concrete and steel, are two car dumpers and next to them are balancing bins, into which certain of the belt conveyors empty. On the pier are four travelling loading towers that can serve as many ships, all at one time. They are supplied with coal by sixty-inch belts, having a maximum speed of five hundred feet per minute. Supplementing these are two towers that trim the ships' loads. The functions of the entire plant are interlocked and controlled electrically by push buttons.

Letter to the Editor

MR. TYE'S RAILWAY PAPER.

Sir,—In three or four issues of your paper you have published "resumees" of the majority and minority reports of the Commission to Enquire into Railways and Transportation in Canada, as also Mr. Tye's paper in full, in addition to some editorials on the subject. It is somewhat significant, perhaps, that while Mr. Tye's paper was read before the Canadian Society of Civil Engineers in public, and the widest publicity was given to it throughout the country, no advance notice of such a paper was sent out and consequently there was no chance for discussion or criticism at the time it was read.

After the reading comments were invited, but these will be presumably bound up with the proceedings of the society, and will be seen by no one but the members. In view of these facts I would ask you to publish my reply to Mr. Tye as given to the Canadian Society. There are two sides to every question and it is only fair that the railways criticized should have a chance to present their side and to point out the errors and inaccuracies in the originals.

HENRY K. WICKSTEED, B.A.Sc.,
Chief Engineer Location, C.N.R.

Toronto, Ont., June 8th, 1917.

[NOTE.—*The Canadian Engineer* did not know that Mr. Wicksteed had written a letter to the Canadian Society until his letter of June 8th was received. We have pleasure in reprinting herewith the copy of the letter to the society which was enclosed in Mr. Wicksteed's letter of June 8th. The letter to the society was dated April 16th, 1917, and was addressed to the secretary at Montreal. Following is its complete text.—EDITOR.]

The writer has read with much interest Mr. Tye's paper on "Canada's Railway Problem and Its Solution," and must compliment that gentleman on its preparation. At the same time, there appear to be some points in it to which exception may be taken and others which will bear amplification.

Taking Mr. Tye's conclusions in order:—

1. The National Transcontinental, the Grand Trunk Pacific and the Canadian Northern railways are unable to earn their operating expenses and their fixed charges. Canada has built, and is operating, the first of these roads, and Canada and the various provinces have guaranteed the principal and interest of most of the bonds of the other two. As the roads are unable to earn their fixed charges, they must, of necessity, be paid by the country.

Regarding conclusion No. 1.—This gives the impression that the Canadian Northern has not at any time paid, nor has any definite prospect of paying, its fixed charges. Mr. Tye shows further on that so long as the Canadian Northern remained west of Port Arthur it was wonderfully successful, and if his paper had been written after instead of before the publication of the last annual report, he would probably have modified his conclusion as to its prospects in the future. If in the first year of operation of the full system a deficit of only $258,000 is shown, the prospects for the future must be admitted to be very good indeed.

2. The failure of these roads is due to the duplication of lines by all the railways, encouraged and bonused by the government; to the excessive cost of the Grand Trunk Pacific and National Transcontinental railways; to the failure of the Grand Trunk Pacific to provide itself with an adequate

system of feeders in the west, and to the construction, by the Canadian Northern, of the long and unproductive stretches of road across British Columbia and Northern Ontario, without feeders, terminals, etc.

Conclusion No. 2.—The writer deplores with Mr. Tye the duplication of lines by the different Trunk Systems, but would point out that as far as the Canadian Northern is concerned, the "long stretches" of unproductive line were forced on it by the construction of the Grand Trunk Pacific and Transcontinental Railways as a measure of self-preservation. It had lines both east and west, the latter earning handsome returns and the former "doing well" (they have since become self-supporting). It was obvious that when connected up they could be reasonably expected to do much better, and this has, the writer submits, been definitely proved by the results. The parallellism came from the Transcontinental and Grand Trunk Pacific.

The "stretches" are long, assuredly, but the unproductiveness is hardly proven. There is very good reason indeed for believing that both of these stretches will in a comparatively short time yield very good returns indeed for local traffic alone. The unproductiveness is on account of their newness. The policy of the Canadian Northern, the policy of the state, has been to construct in advance of development rather than to await it, and the progress of Canada's commerce scarcely seems to bear out the proposition that the policy has been in error.

3. If the Canadian Northern, the Grand Trunk Pacific and National Transcontinental be maintained in two separate systems, it will cost at least $400,000,000 to build the necessary branch line feeders and terminals, to provide them with adequate rolling stock, and put them in proper physical condition to compete with the Canadian Pacific.

No. 3.—As far as the Canadian Northern is concerned, only a small fraction of the sum Mr. Tye mentions is necessary to put it upon a self-supporting basis, which is all we are at present concerned with. Except in the metropolitan cities, the territories served by the Canadian Northern and Canadian Pacific are fairly well defined and separate.

4. It will be necessary that the Grand Trunk Pacific build five to six thousand miles of feeders in the west.

5. It will be necessary that the Canadian Northern build two to three thousand miles of feeders in the east, and terminals costing many millions in Montreal, Toronto, Ottawa, Quebec and Vancouver.

No. 5.—The Canadian Northern has in contemplation in the east a very limited number of miles which it considers essential,—scarcely over one hundred. As to terminals, those in Montreal are well advanced towards completion. In Toronto and Ottawa the same may be said. In Quebec the Canadian Northern is probably better situated than any other road and only in the matter of a passenger station is it behind the C.P.R. In Vancouver its terminals are also in progress.

6. Canada has already sufficient railway mileage for years to come. The additional mileage necessary for these roads could only be had by duplicating existing lines. Such duplication of lines would only add to the burden to be borne by Canada in the way of subsidies, guarantees, etc., without doing the country any good.

No. 6.—This must be admitted as nearly true if Mr. Tye refers merely to mileage in itself and not to the position of such mileage, but if he means that no more mileage should be constructed anywhere for many years to come, the writer cannot by any means agree with him. This would be tantamount to saying that Central Canada is fully developed and settled and has no resources outside of the territory now occupied, and that further expansion should not be encouraged. To such a proposition the writer cannot subscribe. He believes that there is very much more to be done in the way of expansion and that any unnecessary mileage constructed is that due to one road's invading the territory already served and developed by another; in short, to duplication; but it does not follow that the same amount of mileage judiciously placed will not be a necessity in a short time if development is to continue.

7. Canada has sufficient railway mileage and traffic for two good transcontinental systems—the Canadian Pacific and another—but not enough for three.

No. 7.—The writer would repeat that the policy of Canada has been to build in advance of settlement and it seems to have been a successful policy. What the future may show we cannot tell. The invasion of the northern part of the prairie provinces by the Grand Trunk Pacific is unfortunate and would seem to be unwise. In the east there is little interference by the Canadian Northern with any existing system.

8. A consolidation of the Grand Trunk, the Grand Trunk Pacific, Transcontinental and Canadian Northern railways would give a well-balanced system. The Grand Trunk has an excellent system in the east, with terminals in all large and important centres; the Canadian Northern has not. The Canadian Northern has a good system of feeders in the west; the Grand Trunk has not. Each is strong where the other is weak. Combining them must, of necessity, be the most economical and efficient way of handling the situation.

No. 8.—The writer agrees with this principle in part but objects to some of the statements made in support of it. The Grand Trunk has nothing in the northern part of the provinces of Quebec and does not enter Quebec city at all. Surely Quebec, Three Rivers, Joliette, Grand Mere, Shawinigan Falls and Chicoutimi are important centres, as well as Hull, St. Jerome, La Tuque and Lachute.

9. Such a combination would not require more than $100,000,000 to provide it with sufficient rolling stock and to put it in proper physical condition to compete with the Canadian Pacific.

10. The saving in capital cost would be at least $300,000,000 and, at present rates of interest, the saving in fixed charges, at least $15,000,000 per annum.

Nos. 9 and 10.—Granted. But the Canadian Northern does not need this expenditure to make it self-supporting.

11. The Transcontinental cost $100,000 per mile to build The parallel Canadian Northern cost less than $50,000 per mile, and is, in every way, as efficient an instrument of transportation. The Quebec bridge, with approaches, will cost $40,000,000, and will not be necessary for many long years to come.

12. The Transcontinental, including the Quebec bridge, has cost Canada at least $100,000,000 more to build than it would have cost the Canadian Pacific to build as efficient a road.

Nos. 11 and 12.—Quite true, but it is not quite obvious why Mr. Tye has picked out the Canadian Pacific as the only efficient railway builder.

13. Including operating expenses and fixed charges, it costs the Canadian Pacific about $70 to do $100 worth of business. Including operating expenses and interest on cost, it costs the Intercolonial and the other Canadian government roads from $200 to $220 to do $100 worth of business.

14. Canada should follow the wise example set by Sir John Macdonald when dealing with the Canadian Pacific in 1879-80, and form a new private corporation, with sufficient power and the necessary safeguards, to take over and consolidate the Grand Trunk, Grand Trunk Pacific, Transcontinental and Canadian Northern railways, and develop another Canadian Pacific, rather than to have the government take them over and develop another and a vaster and more expensive Intercolonial.

15. Conditions for the formation of such a company are much more favorable than they were in 1880, as western Canada had not then been proven, as it since has been, to be capable of supporting a large and prosperous population.

16. Such a combination would start with gross earnings of at least $100,000,000 per annum, with a probable average

increase of 8 per cent. per annum, and probable net earnings of from $25,000,000 to $30,000,000 per annum, and a net revenue from other sources of about $2,800,000.

17. Its fixed charges at consolidation would be about $35,000,000, and it would be under the necessity of spending, in the first five to seven years, at least $100,000,000 to provide rolling stock and to put its properties in good physical condition.

18. Deficits for some time to come would be inevitable, owing to the heavy fixed charges amounting to about $35,000,000, as compared with $10,300,000 per annum for the Canadian Pacific.

19. As these high fixed charges are caused by the excessive cost of government construction and by duplication of lines, bonused and guaranteed by the government, Canada must pay them.

20. The fixed charges would be at least $15,000,000 less with one private system than with two, and very much less with private than with government management.

21. With such a combination as has been outlined, the series of deficits should not last more than five to ten years, after which the road should be very successful.

22. In order to control its policy, and to share in its certain prosperity, Canada should have an interest in the new company. The Dominion government should furnish 40 per cent. of the money required, own 40 per cent. of the stock, and appoint 40 per cent. of the directorate, but take no part in the actual management. This would give all the advantage of government control without any of the manifest disadvantages of government management.

23. Once this combination was successful, Canada should once and for all abandon the vicious policy of bonusing railway construction, either by gifts of money or land, or by the still more vicious policy of guaranteeing the bonds of railway companies of which it has no direct control.

Nos. 13 to 23.—Mr. Tye's object seems to be to show that the government can get out of a bad bargain by consolidating these roads and putting up $100,000,000, better than in any other way. Is this the whole duty of a government? The Canadian Pacific and the Canadian Northern have both been built under this so-called "vicious" system of bonusing and guaranteeing, and both have done wonders in opening up the country. Could they have been built otherwise? The experiment was tried in the case of the C.P.R. and abandoned. It was tried again in the case of the Transcontinental and Mr. Tye condemns the experiment as an absolute failure, which it is.

The C.P.R., in spite of the enormous subsidies granted it, came very close to failure at least once in its early career, and the government came to its assistance. It had no opposition. The Canadian Northern, with less assistance, has fought its way for a perfectly logical development at almost every step. Its financial success may be said to be certain, but a perfectly unforeseen series of contingencies have deferred such success. It has admittedly rendered an enormous service in the development of the country. Under these circumstances is there a moral right to deprive its owners of their property and the fruits of their labors? Such work as these men have done is impossible for a government such as ours to do. Mr. Tye clearly shows this. Without the stimulus of profit, without exemption from interference, private individuals will not undertake it, and in spite of the implied negative contained in consideration 22, there is much development work still to be done in Canada, and the writer is very doubtful whether there is any better way of securing it than by grants of land worthless without such development.

Probably Mr. Tye will contend that it is not confiscation but consolidation which he proposes, but if the Canadian Northern is to be loaded down with the enormous debt of the lines which it did not create; with the creation of which it had nothing to do except by its initial success to point the way; the result is surely much the same, and the discouragement to private enterprise, to thrift, intelligence, courage and perseverence will probably have a worse effect on the moral and material progress of the country than can be offset by any financial gain or saving.

The government now owns 40 per cent. of the stock of the Canadian Northern and will participate in any value which this will have in the future and in any dividends which may accrue. Would it not be better that the lines which the government has built, and the Grand Trunk Pacific have built with liberal government aid, and which are continuous with one another across the continent, should be allowed to work out their own salvation? The writer heartily agrees with Mr. Tye that their building was a mistake. Should not the mistake be paid for by those who are responsible for it? And should a perfectly legitimate and logical enterprise which but for this mistake would already be a financial success, be burdened with it?

To accuse Mr. Tye of unfairness is the last thing in the writer's mind, but there are several points on which he is evidently misinformed. Some of these have been pointed out. Quebec terminals, for instance, and the financial status of Quebec lines generally. In the case of the Montreal terminals he submits a map which is somewhat misleading. The city extends nearly to the Back River, the map not nearly so far. Hence the Canadian Northern yards at Cartierville do not appear in the picture at all, nor does the extension of the line to the Lachine Canal, nor anything but the fag end of the eastern line through Maisonneuve, along which such a phenomenal development has taken place.

The policy of the Canadian Northern has been in Montreal and elsewhere to create development, not to follow it. A passenger terminal in the city proper, and a freight yard for receipt and delivery, were considered necessities; a sorting and classification yard in a central locality was not so considered. The line through Maisonneuve was built 15 years ago through farm property. To-day it has tributary to it some of the greatest industries in the city or the country, and a population of 40,000 people along its tracks. This seems to the writer to be a line of development which deserves a good deal of credit.

The unfortunate delay in the completion of the Mount Royal Tunnel, owing to the unprecedented financial situation, has undoubtedly contributed more than any other element to prevent the Canadian Northern from making an even better financial showing than it has. Not only has the large expenditure on the tunnel itself and on the terminal property been earning no interest, but the whole line west to Port Arthur, 1,000 miles, has suffered and been comparatively unproductive through the delay in the completion of this terminal.

Imagine the Grand Trunk or the C.P.R. with its Montreal terminals wiped out for three years! The one road would be ruined and the other very seriously embarrassed.

The writer would repeat that the C.N.R. asks for nothing in the west or centre but a little patience and forbearance on the part of the public while it works out its own problems. Mr. Tye gracefully endorses the high standard of location and construction of its new lines. Another high authority pronounces them the "best in existence." If the older portion of the system in the prairie provinces is not quite up to the standard of the balance of the main line on either end, the reason is obvious. This is the colonization or development portion and there is no greater evidence to the writer's mind of

the business acumen of the builders of both the Canadian Pacific and Canadian Northern than this: that they kept their capital charges low in the early day of development.

Mr. Tye himself shows that there is no more severe condemnation which can be urged against the National Transcontinental and the Grand Trunk Pacific than their enormous cost through undeveloped territory. Development roads are needed in Canada, many miles of them, but development roads have no right to cost $100,000 per mile, and there can be little excuse for the construction of the National Transcontinental except development.

The Canadian Northern to-day between Winnipeg and Edmonton is an infinitely better line than the Canadian Pacific of 25 years ago between the same meridians, and the money required for betterments comparatively trifling. The main line will then be, as it now is, for three-fourths of its length (to quote the same high authority again), "the best long-distance line in existence." This applies not only to its standards of grades and curvature, but to the selection of its general route and the territory which it serves. This is no reflection on the work of the C.P.R. men in earlier days. There were reasons for its more southerly location across the prairies and around Lake Superior other than the attainment of the best physical standards.

The C.N.R. started where the C.P.R. left off, and with the benefit of its experience as well as that of the American lines. If it had not profited by the lesson the reflection would have been on the executive of the newer road.

[NOTE.—The following paragraphs were not included in the manuscript sent to the Canadian Society, but are included in the manuscript sent to *The Canadian Engineer* with a note from Mr. Wicksteed to the effect that they are additional paragraphs.—EDITOR.]

Mr. Tye shows that the cost of the Transcontinental and G.T.P. is excessive. The writer heartily agrees, but granting the extravagance, are they altogether useless? and being built, is it quite unreasonable that a government should keep them in repair? One of the functions conceded to a government is regulation of rates and tariffs. What better check on unfair tariffs could there be than a first-class road connecting the main centres? The plea for the Trent Valley Canal was that it would put a check on freight rates.

The Intercolonial and the C.P.R. were first projected as "political" necessities, as a continuous binder between the provinces. The I.C.R. remained in the hands of the government, the C.P.R. passed into private hands and became a commercial power. The I.C.R. became a burden to the country, but not an insuperable one, and during the last months of military operations has been an essential factor.

May not the N.T.R. and the western section of the G.T.R. make the same plea for existence, that they may some day be a military necessity? The C.N.R. and C.P.R. are both vulnerable on Lake Superior and along the Fraser River, so are the St. Lawrence and the Welland canals. The N.T.R. and Intercolonial are safe, and while a possible difference with our southern neighbors seems a more remote possibility than ever before, quarrels do occur in almost unexpected ways, and "preparedness" is the best antidote and the modern by-word. Germany's experience seems to be that military railways are the best form of "preparedness."

A function which has never as yet been ascribed to any government is that of active competition with private mercantile ventures. Aside from the impossibility of economical management which has been often pointed out, the ethical principles involved in a government's using its unlimited credit and power to destroy the business of a privately owned competitor seems altogether indefensible. Whatever may be urged for nationalization of all railways (and it seems to be very hard to make out a case), competition is unpermissible because of the inequality of the competitors.

HOW KITCHENER FIRED ITS CITY ENGINEER.

Under the above heading, The Toronto Star last Saturday published the following special dispatch from Kitchener, Ont.:—

A case of considerable interest was heard before Magistrate Weir yesterday when Alderman P. M. Bowman appeared to answer to the charge of offering material consideration to Alderman Jack Reid, contrary to the Municipal Act, if he would come back from Owen Sound and vote for the dismissal of Engineer Johnston.

There was also a second charge, that of offering Alderman Brubacher certain things in reference to his assessment if he would vote all right. From the evidence adduced the dismissal of City Engineer Johnston was a part of the propaganda of the Citizens' League, as Bowman told Reid that the Citizens' League would pay his expenses and railway fare if he would come back from Owen Sound and vote for the dismissal of Johnston at the April council meeting.

Alderman Brubacher in his evidence stated that he had been visited by Alderman Bowman, who told him that certain members of the city council couldn't understand why Brubacher was taking the position in favor of Johnston, and he (Brubacher) told them that he had always found him all right, and would support him. The witness was told that some of the aldermen were in favor of putting in the east end storm drain which affected his property. Bowman then told him that there was a meeting that night and "if you cannot vote in favor of Michel, you had better stay away from the meeting."

In the matter of Alderman Reid, he told of having been called upon twice at his home by Bowman to try and arrange for Reid to come back from Owen Sound to vote on the engineering question, and after he had gone to Owen Sound, of receiving a telephone communication asking him to come back. In the matter of who was to pay expenses, Bowman had said: "I believe the Citizens' League will pay them."

After hearing the evidence for the prosecution, Magistrate Weir adjourned the case until June 26th.

FUEL COMMISSIONER FOR CANADA.

Charles A. Magrath, C.E., D.T.S., chairman of the Canadian section of the International Joint Commission, has been appointed special commissioner to deal with the fuel situation in Canada. Wide powers are conferred upon him, including the fixing, if necessary, of prices. Authority will also be given to take over and operate as a war measure the mines in the Crow's Nest country, where operations are tied up by a strike. The coal situation and the outlook for next winter are considered so critical that the government decided that there must be a central authority having drastic powers of regulation of supply and demand. The action was taken under the War Measures Act. Mr. Magrath will enter upon his duties immediately and will work in conjunction with the Railway Commission in equalizing distribution.

THE DESIGN OF A TOWER FOR A 50,000-GALLON HEMISPHERICAL BOTTOM TANK.*

PERHAPS the most common size and type of elevated steel water tank in use to-day is the 50,000-gallon tank with hemispherical bottom. Its average height is about 75 feet and it is usually supported on a four-post tower. We will attempt to go through the various steps in the design of the tower in the shortest and simplest way.

The structure must be strong enough to withstand the following loads: (1) The water in the tank; (2) the weight of the tank and tower itself; (3) the wind load.

Other loads sometimes considered are snow on the roof, and the weight of people on the balcony, but it is evident that snow would not stay on a roof while the maximum wind load was acting, and it is not customary for any one to take a pleasure trip up to the balcony of an exposed water tower when a hurricane is blowing at the rate of 100 miles per hour.

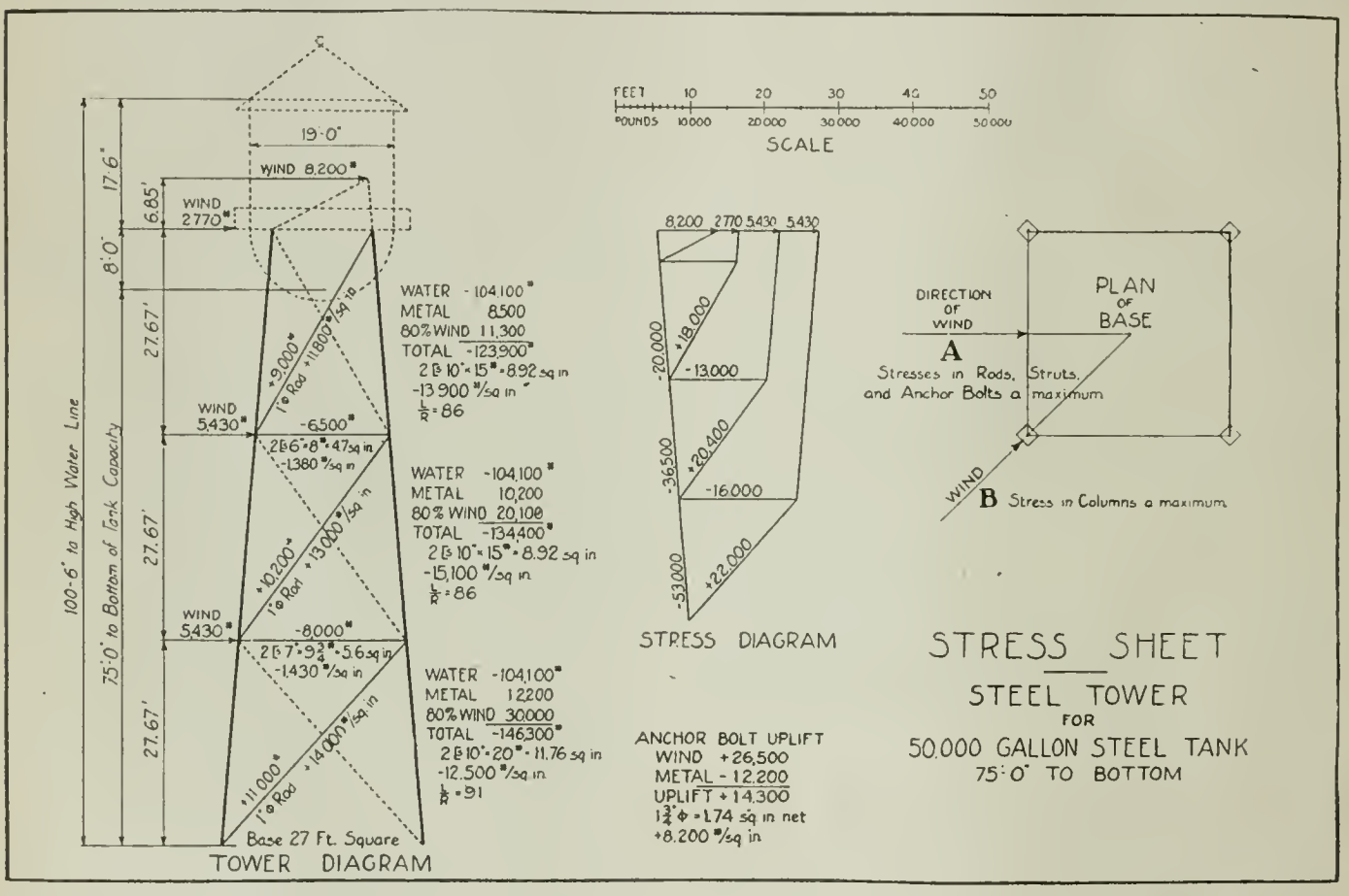
The stresses caused by the above loads will be considered in the order given.

(1) Water Load.—The weight of the water is transmitted directly to the foundations through the columns. The struts and rods receive no part of this load. Each column takes one-quarter of the total water load, or 104,100 pounds. Opposite each panel on the diagram is given the loading on the columns. The water load is given first and it remains the same in each panel.

(2) Metal Load.—The weight of the tank and tower itself, or metal load, can be only approximated at first. After the design is finished and the total weight of the structure is calculated, the correct metal loads can be substituted, and the stresses recalculated.

(3) Wind Load.—The maximum wind velocity in any part of this country will produce a pressure of about 15 pounds per square foot of projected area on a surface such as that of a hemispherical bottom tank. For the particular tank given this load is 8,200 pounds, and it is considered acting at the centre of gravity of the projected area, which is 6.85 feet above the balcony line.

It is common practice to assume the wind load on a four-post tower to be 200 pounds per vertical foot and to assume that it acts at the panel point, or strut line. The tower is 83 feet to balcony and has three panels of 27⅔ feet each. The tower wind load is then 2,770 pounds at the balcony and 5,430 pounds at each panel point. These loads are shown on the tower diagram with arrows indicating their direction and point of application.



*From "The Water Tower," published by the Chicago Bridge & Iron Co.

The wind stresses are usually determined by the graphical method, as this is perhaps the easiest and quickest way. It is not material just how the stress diagram is drawn; although the result should be the same as that shown, another system may give a diagram in the reverse order. In the case given, the loads were laid off at the top and the forces were taken counter-clockwise around each point.

The maximum stresses in the rods and struts occur when the wind is blowing from direction A. These stresses are one-half of those obtained from the stress diagram, as the wind loads used in drawing the diagram were the loads for both sides of the tower.

The maximum column stresses occur when the wind is blowing from direction B and they are equal to .707

(Continued on page 505.)

PUMPING IN THE METROPOLITAN WATER DISTRICT OF MASSACHUSETTS.*

By A. O. Doane,
Division Engineer, Metropolitan Water Board, Boston.

THE Metropolitan Water District of Massachusetts was established by an act of legislature in 1895. It includes the city of Boston and seventeen other neighboring cities and towns, and had an estimated population in 1916 of 1,190,220. The average daily consumption of water in the district for 1916, of which half was supplied by gravity, was 103,876,000 gallons or 87.3 per capita.

The water supply is obtained from the old Boston reservoir No. 3 on the Sudbury River, the Sudbury reservoir (commenced by the city of Boston and completed by the Metropolitan Water Board), and from the Wachusett reservoir, constructed by the board on the south branch of the Nashua River at Clinton. Lake Cochituate, from which the first large supply for Boston was obtained, and the old Boston reservoirs on the Sudbury River, except reservoir No. 3, are now held in reserve.

Half of the water drawn from the Wachusett and Sudbury reservoirs is brought to a point in Weston, through the Weston aqueduct. It then flows through 60-inch and 48-inch cast-iron pipes and furnishes the gravity supply to the lower parts of the district. Spot Pond, in the extreme northerly part of the district, is connected with this pipe system and acts as a storage and compensating reservoir. The remainder of the water drawn from these reservoirs, together with the water from the old Boston reservoir No. 3, is conveyed by the Sudbury aqueduct to Chestnut Hill reservoir. All this water is pumped at the Chestnut Hill pumping stations. When water from Lake Cochituate is used, it comes to Chestnut Hill Reservoir through the Cochituate aqueduct.

On January 1, 1898, the city of Boston pumping stations came under the control of the Metropolitan Water Board, and the Mystic pumping station and several of the smaller stations in the district were shut down. When the new Metropolitan pumping stations were completed, all of the small pumping plants were abandoned, and all the pumping for the district is now done at five stations by high duty pumping engines instead of at seventeen widely separated stations by low duty pumping machines of a type now obsolete.

All the water delivered to the Chestnut Hill reservoir is pumped at two pumping stations located on the southeasterly side of the reservoir. The older building, known as Chestnut Hill pumping station No. 1, was built by the city of Boston in 1887.

The pumping plant consists of two 8,000,000-gallon Gaskill horizontal fly-wheel engines, built by the Holly Manufacturing Co. in 1887; one 20,000,000-gallon vertical triple expansion crank and fly-wheel engine, designed by the late E. D. Leavitt and built by the Quintard Iron Works in 1895 (this engine has Riedler mechanically operated valves in water end); and one 30,000,000-gallon vertical triple expansion crank and fly-wheel engine, built by the E. P. Allis Company in 1898.

The boiler plant consists of one Belpaire boiler, 90 inches in diameter and 34 feet long; two vertical Dean boilers, 98 inches in diameter and 24 feet long; and three horizontal tubular boilers 64 inches in diameter and 18½ feet long. There is also a 168-tube Sturtevant economizer.

*Paper read before the American Water Works Association, May 8th, 1917.

Only a comparatively small quantity of water is now pumped at this station, as most of the water for the supply of the higher portion of the southerly part of the district is pumped at pumping station No. 2 by the 40,000,000-gallon Holly pumping engine.

Chestnut Hill Pumping Station No. 2.—This station was built by the Metropolitan Water Board in 1900. The pumping plant consists of four vertical triple expansion crank and fly-wheel engines, all built by the Holly Manufacturing Co.; three of these engines are of 35,000,000-gallon capacity each and were installed in 1900, and the fourth is of 40,000,000-gallon capacity and was erected in 1911.

The boiler room contains five boilers, all of the vertical fire tube type, designed by F. W. Dean. The three older boilers are 98 inches in diameter, 29½ feet high over all, and each contains 384 2-inch tubes 15 feet long. The other two boilers are 109 inches in diameter and 29½ feet high over all, and each contains 484 2-inch tubes 15 feet long.

There are two 144-tube economizers, one a Sturtevant and the other a Green.

The coal house has a capacity of 1,000 tons, and the loaded cars come into it on a trestle about 15 feet high. An ash tunnel extends under the boilers, and the ashes are dumped through an opening in the floor into a car in the tunnel. The loaded ash cars are raised to tracks outside the building leading to a dump, by means of a hydraulic elevator.

The 40,000,000-gallon engine is used for supplying the southern high-service district and operates against an average head of 124.54 feet. The three older engines pump water for the lower parts of the district, including the low-lying portion of the city of Boston.

Owing to a large increase in the amount of water supplied by gravity, the pumping to this service has been much reduced and the pumps are now largely used to regulate the pressure in the mains by supplying water during periods of maximum draft and to raise the pressure during large fires.

The combined daily average high service pumping at both of the Chestnut Hill pumping stations was 34,371,300 gallons in 1916; the average lift was 124.13 feet; the cost per million gallons pumped, based on pumping station expenses, was $3.0682.

The low-service pumping was done at station No. 2, and amounted to a daily average of 33,875,000 gallons from January 1 to February 7, 1916. On February 8 a large main supplying water by gravity from the Weston aqueduct was put in service, and the daily average pumping for the remainder of the year was 15,365,000 gallons. The average lift was also reduced from 41.51 feet to 33.70 feet. The change, while reducing the total cost of water pumped about $4,000, raised the cost of pumping per million gallons to $4.14, of $1.80 more than in 1915.

The Spot Pond pumping station is situated on the shore of Spot Pond. The engine room contains a Holly 20,000,000-gallon vertical triple expansion crank and fly-wheel engine and a 10,000,000-gallon vertical compound crank and fly-wheel engine designed by the late E. D. Leavitt and built by the Blake Manufacturing Co. This engine was erected at the Mystic Pumping Station of the city of Boston and was transferred to Spot Pond in 1899, after the Mystic station was abandoned.

The boiler room contains three Dean vertical internally fired fire tube boilers 92 inches in diameter, 29 feet 4 inches long over all, each containing 256 2¼-inch tubes 15 feet long.

A Green 144-tube economizer is used to heat the boiler feed water.

The water is pumped from Spot Bond to the Fells and Bear Hill reservoirs. From these reservoirs it is distributed to the higher portions of the northerly part of the district. The daily average quantity pumped in 1916 was 7,106,000 gallons, against an average lift of 129.06 feet. The cost of pumping was $5.8289 per million gallons.

The northern extra high service pumping station is located in Arlington and pumps water from the low service system for the supply of the higher parts of the town of Arlington and for the entire supply of the town of Lexington. The pumping plant consists of one Allis-Chalmers cross-compound crank and fly-wheel engine and one Blake compound duplex engine used as a reserve pump. Both have a daily capacity of 1,500,000 gallons.

There are two 54-inch horizontal tubular boilers in brick settings.

The daily average pumping in 1916 was 797,000 gallons; the average lift was 281.7 feet; and the cost per million gallons pumped was $36.42. This was partly due to expensive repairs to the Allis-Chalmers engine and more extended use of the low duty Blake pump.

The southern extra high service pumping station is located in the Hyde Park district of Boston, and pumps water from the southern high service mains for the supply of elevated territory in the southern part of the district.

The station contains two 3,000,000-gallon cross-compound crank and fly-wheel engines built by the Laidlaw-Dunn-Gordon Co., and two 54-inch horizontal tubular boilers in brick settings. The daily average pumping in 1916 was 655,000 gallons; and the cost per million gallons pumped was $30.31.

The five pumping stations are operated under the direction of the superintendent of pumping stations, Arthur E. O'Neil, who reports to Mr. William E. Foss, chief engineer of waterworks. The men work in eight-hour shifts, and are allowed one day off in seven and a vacation with pay.

Coal and lubricating oil are purchased under specification and are regularly tested at a laboratory at the main office of the board in Boston. In addition to the laboratory tests of fuel, special boiler tests are made from time to time, especially when changes in the brand of coal used are contemplated. In this way much information regarding the actual working of the coal is obtained, which is not shown by the calorimeter or other laboratory tests.

Synopsis of Coal Specifications.—The coal shall be of good quality, free from dirt and excessive dust, a sample of which when dried at 221° F., hereinafter called dry coal, will approximate the following standard of heat value and analysis:—

British thermal units	14,800 per pound.
Volatile matter	18 to 20 per cent.
Ash	7 per cent.
Sulphur	1 per cent.

Coal which when dry contains less than 14,300 British thermal units per pound, more than 23 per cent. of volatile matter, more than 9 per cent. of ash, or 1.50 per cent. of sulphur may, at the option of the chief engineer, be rejected, and if rejected shall be removed by and at the expense of the contractor.

Payments.—For each 50 British thermal units or fraction thereof in the dry coal in excess of 14,800 the price per ton shall be increased one cent, and for each 50 British thermal units or fraction thereof less than 14,700 the price per ton shall be decreased two cents.

For each ½ of 1 per cent. or fraction thereof of ash in the dry coal in excess of 8 per cent. the price per ton shall be decreased one cent.

When the analysis of the coal shows moisture in the coal as received in excess of 3 per cent., the amount of weight due to moisture in excess of 3 per cent. shall be deducted from the total weight of the coal, and the net weight so determined shall be taken as the amount of coal to be paid for.

Coal for the pumping stations has been purchased on the heat unit basis since 1908, the board having been one of the pioneers in adopting this method of buying coal.

The specifications as outlined above have given general satisfaction and are fair to both dealer and consumer, which is an important point.

Fuel suited to the type of boiler, as well as draft and load conditions, is obtained and any loss of efficiency due to a poor lot of coal is compensated by the reduction in price.

Limiting the volatile matter is of considerable importance where vertical internally fired fire tube boilers are in use, as it is difficult to obtain complete combustion of a high volatile coal before the gases strike the heating surfaces of the boiler.

The limitation of sulphur is desirable, as the element in combination with iron and other constituents of the ash is apt to form bad clinkers, and also from the fact that the presence of 2 per cent. or more of sulphur is in most cases a very good indication that the coal is liable to spontaneous combustion. While it is well known that this action is due to absorption of oxygen by the coal, both sulphur and moisture seem to play an important part in starting the trouble, although some coals low in sulphur heat badly while others high in sulphur do not.

As the greatest opportunity for economy is commonly found in the boiler room, particular attention is paid to this part of the plant. Care is taken to see that the method of firing and depth of coal on the grates is suited to the fuel and load, that the tubes and heating surfaces and other parts of the boiler are kept clean, and the boilers are washed out at regular intervals. Particular care is taken to keep the lower tube sheets of the vertical boilers free from scale to avoid overheating the tube ends. The brick settings of horizontal boilers require careful watching to avoid infiltration of air through cracks or porous masonry.

Recording steam gauges have a considerable moral effect on the firemen, and in connection with log charts giving the hourly readings of instruments in the engine and fire rooms keep the superintendent informed of what goes on in the plant during the entire 24 hours.

An apparatus for the continuous determination of CO_2 is installed at pumping station No. 2, but has not proved very satisfactory in operation as, owing to its delicate and complicated construction, it is liable to get out of order and requires more expert attention than it is practical to give.

Leaks in steam pipe lines are promptly repaired, as it is astonishing how much loss may be caused by an apparently insignificant leak.

There are four fuel economizers in service, but the conditions are not favorable for large savings owing to the steady load and large proportion of heat absorbed by the boiler heating surface, with consequent low flue temperature. The economizers do, however, act as settling reservoirs and to a limited extent as feed water purifiers, and as steam-driven auxiliaries are scarce in the Metro-

politan stations they add some heat to the feed water, which would otherwise have to be obtained from live steam in order to comply with the state law, which requires boiler feed water to have a temperature of at least 120° F.

Careful attention to methods of firing, such as depth of fire, regulation of draft, working of fire, charging and spreading of coal, makes for economy. As a general rule, charging small amounts of coal frequently and maintaining as thin a fire bed as practicable give the best results. Hand firing is the method employed, although stokers have been used and also forced draft with hand firing. There is considerable danger in using forced draft in internally fired fire tube boilers of getting a blow pipe or Bunsen burner effect, causing intense local heating which results in burning the furnace sheets or crown sheets and tube ends.

It has been found economical to burn a certain proportion of small anthracite coal, known as Birdseye, mixed with bituminous coal. From 25 to 50 per cent. of Birdseye can be burned with advantage with natural draft, depending on the draft available, load conditions and depth of fuel bed and characteristics of the coal used in regard to coking and clinkering. A larger proportion of Birdseye can be used economically by carrying a thin fire bed, taking care to avoid the formation of holes and working the fires as little as possible. If the air supply is obstructed by a thick fuel bed or formation of clinkers, imperfect combustion ensues. If the fire is sliced or shaken too much, a large proportion of the fine coal falls into the ash pit unburned.

One advantage of using a considerable proportion of anthracite is that it greatly reduces the formation of smoke; another is that mixing it with a bituminous coal having an ash of low fusibility tends to prevent the formation of a layer of melted ash, which would cut off the air supply to the fuel bed.

The boiler feed water is metered and in most cases it is necessary to use a hot water meter. Various makes of these instruments of the disc, piston or rotary type have been tried, but all are unsatisfactory as they rapidly lose accuracy and require constant repairs. A Venturi meter gives the best results, as there are no moving parts in the hot water, but the great cost of the registers makes them out of the question for most small plants.

It has been found advantageous to use as small steam pipes as will allow of the proper admission of steam to the engine, and by the use of a large separator on the engine the size may be still further reduced.

The advantages of a small pipe are low first cost of pipe, fittings and coverings, less radiating surface and consequent condensation, quicker passage of steam from boiler to engine, and greater flexibility of bends which reduces the strains due to expansion and contraction. The small size pipe is particularly advantageous when the steam is superheated.

While no large economics are possible in the engine room, care is taken to see that the valves of the engines are properly set, that cylinders and bearings are properly lubricated, that both steam and water packings are in good shape, and that the rubber pump valves are kept in good condition, otherwise there would be an excessive amount of slip. It is found that with outside packed water plungers the slip should not exceed 1½ per cent.

For packing single-acting water plungers, a packing made up in the form of a double wedge has been found satisfactory, as on the discharge stroke the water pressure forces the wedges together and prevents leakage, while on the suction stroke the packing is comparatively loose and causes but little friction.

For packing steam piston rods, metallic packing is used and it wears for years without attention.

Most of the air pumps and feed water pumps are direct connected to reciprocating parts of the main engines, and have the same length of stroke as the main plungers. This arrangement requires but little attention and has the same economy of operation as the main engine, but is not as flexible in operation as the independent steam-driven pumps. The exhaust steam from the latter can be used to heat the feed water, giving a good over-all economy and saving the boilers from strains due to cold feed water.

The action of the long-stroke pumps sets up violent strains in the piping unless it is well protected by air chambers kept filled with air.

Surface condensers are used exclusively. Some are of the so-called waterworks type, where the exhaust steam passes through the tubes and all the water pumped passes through the shell, flowing over the outside of the tubes; while in others a portion of the water pumped is by-passed through the tubes and the steam is condensed on the outside of the tubes. As a rule, the waterworks type gives better satisfaction, as the circulating water is cooler owing to the larger volume, there is no trouble with by-pass devices, and the interior of the tubes is not clogged by any material carried by the water.

The table at the bottom of the page gives the results of duty trials of some of the pumping engines.

The Arlington and Hyde Park engines are of the horizontal cross-compound crank and fly-wheel type; all others are vertical triple expansion crank and fly-wheel engines. The duties are based on plunger displacement, and where not otherwise noted on dry steam and coal.

Results of Duty Trials of Pumping Engines

Location of Engine.	Capacity. Mil. U.S. Gals. in 24 Hours.	Average Lift. Feet.	Duty. Million Foot Pounds per 1,000 Lbs. Steam.	Million B. T. U.	100 Lbs. Coal.	Efficiency Mechanical.	Thermal.
Chestnut Hill Pumping Station No. 1	20	137.48	.....	145.470	150.045	.....	.....
	30	140.35	178.497	157.002	173.869	93.29	21.63
Chestnut Hill Pumping Station No. 2	35*	44.68	157.349	140.533	156.322	88.23	20.50
	40	132.09	175.066	155.547	149.135	90.10	20.01
Spot Pond Pumping Station	20	125.27	173.620	156.592	177.961	96.53	20.85
Arlington Pumping Station	1.5	290.3	115.959†	.....	90.025‡	.....	.....
Hyde Park Pumping Station, Engine No. 14	3	.....	121.022†	111.880	113.488‡	93.2	.....

*Average of three 35-million-gallon engines tested together. †Moist steam. ‡Moist coal.

In regular service the duties are computed weekly on the coal basis, and are therefore records of plant efficiency. It is found that where the conditions are such that the engines can run at rated capacity on 24-hour service, the results compare favorably with those obtained at duty trials, but where the engines are not run continuously or operate below the rated capacity, or as frequently happens are subjected to both these handicaps, the duty is seriously affected and may be only from 50 to 75 per cent. of the trial duty, depending on conditions. The engines at the small pumping stations and the low-service pumping engines are particularly subject to these unfavorable conditions.

The efficiency of the boiler plant is satisfactory. All the larger boilers are of the internally fired fire tube type, and as the load is steady while the engines are running and the boilers have ample heating surface for the work, very little heat goes to waste.

Carefully conducted boiler tests have shown that the Belpaire boiler has a combined efficiency of boiler, furnace and grate of 80.3 per cent., and the Dean vertical boilers of 80.4 per cent. The horizontal tubular type boilers have shown efficiency of 74 per cent. under not particularly favorable circumstances.

In regular service the 109-inch Dean boilers gave for the year 1916 an average evaporation from and at 212° F. of 12.3 pounds of water per pound of coal. The horizontal tubular boilers show from 9.5 to 10 pounds evaporation.

These figures have proved stumbling blocks to certain worthy gentlemen who have proposed to install their fuel-saving devices and have guaranteed a 25 per cent. saving of coal.

The human element as represented by the pumping station force, particularly of the fire-room division, is of the greatest importance. Unceasing vigilance on the part of the supervising authority, careful selection of the help and firm but considerate treatment of the men is necessary to get the best results.

Many large corporations have adopted the policy of paying a bonus to the firemen, based on actual savings effected. This has in many cases effected a notable reduction in the fuel bill. This method, however, seems to be impracticable in state or municipal work.

In conclusion, a word of caution may not be out of place. While economy is desirable, it is well to remember that in the pumping service reliability is of paramount importance, and it does not seem good policy to endanger it by attempting to make small savings in machinery, supplies or labor.

CANADIAN ELECTRIC RAILWAY ASSOCIATION.

At the recent annual meeting of the Association held in the Windsor Hotel, Montreal, the following officers were elected for the ensuing year: President, C. L. Wilson, assistant general manager, Toronto and York Radial Railway, Toronto; hon. secretary-treasurer, Acton Burrows, Toronto.

The Executive Committee is as follows:—J. D. Fraser, director and secretary-treasurer of the Ottawa Electric Railway, Ottawa; A. Gaboury, superintendent Montreal Tramways, Montreal; E. P. Coleman, Hamilton; G. Gordon Gale, vice-president and manager, Hull Electric Railway, Hull; J. S. Mackenzie, purchasing agent, Winnipeg Electric Railway, Winnipeg; H. G. Matthews, general manager, Quebec Railway, Light, Heat & Power Co., Quebec; E. L. Milliken, manager Cape Breton Electric Railway, Sydney, C.B., and Aubrey A. Burrows, Toronto.

CANADIAN ENGINEERS AT THE FRONT.

"Extraordinarily difficult conditions of transportation of men, munitions and supplies have been overcome under the direction of Canadian engineers," says Stewart Lyon, official correspondent for the Canadian Press, in a recent article written for Canadian daily newspapers.

"Engineers from allied countries who have visited Vimy Ridge and the region behind," says Mr. Lyon, "express profound admiration and amazement at the magnitude of the work done in a few months. Thousands of men built the waterworks plants, roads, etc., without which the conquest of the Ridge and the holding of it after its capture would have been impossible.

"The railway system begun by the French during the campaign of 1915, was reconstructed and brought into general use. Under the direction of Canadian engineers, galleries were constructed as quarters for the troops and dressing stations for the wounded. There were water pipes, and a supply for hundreds of thousands of men. There were also storage places for food and ammunition.

"Streams miles back, an abandoned coal shaft and a spring at Vimy Ridge, almost under the Boche lines, were the chief sources of supply. Forty-five miles of 4-inch pipe were laid sufficiently deep to protect them against shell fire.

"It has already been told in despatches of the tremendous labor involved in the construction and maintenance of roads and light railways. Some of the troubles were unique. Trees near the Front were cut down to provide material for plank roads but were found to be full of splinters of shells. Shrapnel and bullets played havoc with the teeth of the saws in the portable sawmills, and as no saws with individual teeth could be obtained, the teeth had to be filed by hand after every break.

"The plank roads and light railways were the only possible means of getting supplies up to Vimy Ridge after our artillery had destroyed the German road system.

"Many breaks occurred in the railway in a single night, but section hands were ready in an instant to repair them. The result was an accumulation of thousands of pounds of projectiles ready for the day of the attack. During a single 24-hour period, 457 tons of explosives were carried on one light railway, which is believed to be a record on the battlefield for a position where the enemy could see every movement for miles behind the front. The result of these engineering devices was a decisive victory which forced Von Hindenburg to throw in reserves which he had hoped to use elsewhere in an offensive. The work of the Canadian engineers helped materially to bring about this result."

The following is a list of Canadian patents recently issued through the agency of Messrs. Ridout and Maybee, 50 Yonge St., Toronto, from whom further particulars may be obtained: William G. Stephenson, coupling devices or apparatus for the vestibules or gangways of corridor rolling stock for railways; Dean S. Harley, portable fire escape; Chapman Double Ball Bearing Co. of Canada, Limited, elevating trucks; Sebastion Z. de Ferranti, electrical transformers; Francis E. Matthews and Edward H. Strange, process for the purification of unsaturated hydro-carbons containing the conjugated double bond; Thomas K. Irwin, treatment of sewage and other waste liquids; Elwood Grissinger, telephone systems; Toronto Type Foundry Co., Limited, thread milling and chamfering attachment for lathes.

STREET RAILWAY NEGATIVE RETURN SYSTEM FOR THE MITIGATION OF ELECTROLYSIS.*

By L. A. Herdt, M.Can.Soc.C.E., and
E. G. Burr, A.M.Can.Soc.C.E.

WITH the rapid growth in the extent of electric railway lines and the traffic carried by them, the importance of providing a proper return of the current from the cars to the power houses and sub-stations and thus protecting piping systems, cables and other underground structures, against electrolysis, should be recognized by electrical railway engineers.

Serious corrosion of pipes, with attending damages, has occurred in various cities, as is well known, and efforts in certain instances have been made to eliminate the danger. However, it is a fact that as engineers are only human and liable to the error of advocacy, namely, seeing only one side of the question, the engineers of both interests, that is, the engineer of the company owning and operating the electric railway, and those of the company owning the underground structures, are still earnestly debating where to place the responsibility for damage done by stray currents. The often recurring result is that lawyers are brought into the debate and the courts become the stage of action. Judgment obtained after long delay is usually a legal compromise with orders for certain measures for the alleviation of the nuisance.

Such measures are rarely far-reaching or fundamental enough to do more than remove the particular cause of complaint for a time. The merry-go-round of suit, judgments, expenditure on measures of alleviation and legal costs, and then recurrence of the trouble continues ad infinitum.

But as times change the street railway systems serving growing urban districts themselves include underground structures consisting of lead-sheathed cables liable to destruction by currents straying from returns.

Thus a community of interest in the proper methods to avoid damage occurs, and the interest of all parties becomes the same. Engineers alive to the necessity of avoiding damage at the minimum cost may then be asked to apply the solution of the problem that will remove the trouble.

Various Methods of Electrolysis Mitigation.—The various methods of electrolysis mitigation which have been for years the subject of discussion can be divided into two groups:—

(1) Those methods applicable to underground pipes and cable systems.

(2) Those applicable to the railway negative returns.

Of the various methods under the first heading, namely, chemical protection of pipes, cement coatings of pipes, insulating joints in piping systems, pipe drainage and cable drainage, none are entirely suitable for general use and cannot be considered as primary means of preventing electrolysis damage. These methods have their usefulness, but they are suitable only to special conditions and cannot be considered as important factors in any general plan for electrolysis mitigation.

Of the various methods covered under the second heading, that is, those applicable to the railway negative returns, such methods are suitable as will keep the track voltage gradient, that is, the voltage drop per 1,000 feet of track within certain limits, and will reduce the overall maximum difference of potential between any two points of the return system, also within limits, as well as those which will increase the resistance from tracks to earth. These methods are fundamental, as they control the causes of the straying of current from the tracks. Experience has shown what limits of track voltage gradient and overall potential differences can be allowed. Some ordinances grade the allowable limits to the density of the traffic, allowing greater latitude in the suburban districts than in the urban ones; for in fixing voltage limitations, the voltage limit prescribed should evidently be largely determined by the degree of development of the underground utilities in that district.

A track construction which results in a relatively high resistance of leakage path from rail to earth is eminently desirable but difficult to provide in city streets with flush rails and paved streets.

In Great Britain, where the operation of electric railways is governed by regulations of the Board of Trade, regulation No. 3 requires that the maximum difference of potential between any two points on the track return shall not be more than 7 volts, and also prescribes current densities in rails equivalent to a voltage gradient limit in the tracks to about one volt per 1,000 ft. at peak load.

That is, it is sufficient to say, that if the voltage gradient nowhere exceeds one volt per 1,000 ft. and the maximum difference of potential between any two points (reasonably remote from one another) on the returns, is not more than 7 volts—these readings taken at peak load—almost complete immunity from electrolysis damage will result. (The peak load is here considered to be the average of the readings for twenty minutes at peak load.)

Under the conditions cited above, any residual current leakage, or electrolysis effect that may occur, can conveniently, properly and equitably be taken care of by the party owning the structures affected, by methods cited above under Class (1).

To reduce the track voltage drop in an electric railway system various methods are in use:—

(*a*) Improvement of condition of bonding of rail joints.

(*b*) Subdivision of load amongst substations properly located.

(*c*) Installation of negative return feeders with the negative bus grounded at the station.

(*d*) Installation of negative return feeders insulated throughout their length and connected to the negative bus which is not grounded but is maintained at a potential lower than ground.

These methods have been applied in various ways.

In general, methods (*a*) should be applied in all cases to the maximum practical degree of perfection.

Methods (*b*), (*c*) and (*d*) all aim at the same result—namely, the taking of current from the tracks at an increased number of points.

Methods (*c*) and (*d*), however, are radically different from one another inasmuch as method (*d*) divides the system into a network of mains with separate feeders, whilst method (*c*) shuts the mains by so-called feeders.

It will be found in general that method (*c*) will require a prohibitive amount of copper to reduce the track voltage gradient and overall difference of potential within the limits stated previously. A glance at appendix A will show that the current density in the return path through the track is so low, when calculated for the equivalent copper section of the rails, that any attempt to shunt the current will require excessively large copper conductors. For example, the conductance of a single track 100-lb.

*Abstract of paper read before the Canadian Society of Civil Engineers, April 19, 1917.

rails is equivalent to about two million circular mills of copper and would require this amount added to shunt one-half of the current. If greater current densities are allowed the current will follow a shunt path through the earth and other underground structures. It may be here stated that the limits of 1 volt per 1,000 ft. is by no means too low, and in congested districts where extensive underground structures are in existence this value may with great advantage be lowered.

In method (*d*), however, since the feeders are only connected to the tracks at its outer end and the negative bar is not connected to the tracks except through the insulated feeders, the voltage drop in them may be any value desirable, without reference to the above-mentioned track voltage gradient or overall difference of potential; and for this reason, the conductor section of the negative feeders can be decided by conditions of economy only. The potential gradients in the tracks depends entirely on the amount of current carried and where this becomes excessive the current is diverted through the feeder.

In a large electric railway system, if this is desirable, the potential gradient need not be entirely in the direction of the station but may be reversed so that the integral of the gradients will give a low value of overall potential differences.

Many railway engineers have claimed that the maintenance of such low voltage gradients as have been specified would require prohibitive expense in copper conductors for heavily loaded street railway systems such as are general on this continent. This is not the case, however. Such claims may be true when method (*c*) is employed; that is, when rails are shunted by the return feeder and the bus connected to ground; but the authors desire to point out that with the insulated return feeder system as outlined above and further described below, such regulation can be easily adhered to at reasonable cost.

The authors thought it would be interesting to the Society to discuss briefly the means by which the modification of the track returns of a street railway system in Canada from method (*c*) to method (*d*) has resulted in a decided reduction of track gradients and overall potential difference, with a consequent disappearance of electrolysis trouble.

Design of the Return System.—The return system of a street railway will be in the form of a network of conductors (the bonded rails) with loads at various points (the cars).

It is only required to consider the negative side of the system since the positive network of trolley wires, mains and feeders has no bearing on the problem with which this paper is concerned. The first step is, therefore, to prepare a plan of the system showing the car position at time of peak load, this data being obtained from the car operating schedules. Average values of current can be apportioned to each car, having due regard to the size of the car equipment and allowance being made for grades and curves, if considered advisable, the whole plan to form a representation of the way the load is distributed over the system.

From data such as that given in appendix A, the resistance of the several parts of the returns can be obtained and the problem becomes a simple power engineering problem of the design of the network to carry the load within the stated limits of potential difference and voltage drop per thousand feet.

The rails form the network of mains and the current from the cars is collected on the network and returned through feeders connected to the station or stations.

It is advantageous at this point to consider the general line of development of a continuous current distributing system for light and power.

A direct current distribution system of small size will naturally take the form of a radial system with feeders run out to the nearest load and continuing therefrom as a main with the loads connected thereto.

The next development will take the form of cross-tie mains connected to the ends of more than one feeder, then further cross mains are installed connecting the outer end of radial mains so that a network is constructed with the radial mains near the station, acting also as feeders to the outer cross-tie main.

In larger systems radial mains cannot feed the outer districts within the desirable voltage regulation limits, and it is necessary either to install additional stations to feed the outer districts or special extra feeders to the outer districts with a means of providing for the extra voltage drop; or, again, the extension of the radial feeders to tap the mains or network at points farther from the station, so that the current from the outer districts is taken from the radial mains at some intermediate point, and the current flows in the main from the nearest loads in a reversed direction.

The choice of method will resolve itself into a question of economics.

It is of special interest to note that in nowise would the alternative expedient of increasing the section of the radial mains be resorted to; as they are normally of large size, a large amount of copper would be required to moderately decrease their resistance, whereas in a feeder having only one point of connection to the load; that is, at the junction to the main, the voltage drop in it can be made any value desirable from consideration of power loss and current-carrying capacity.

All the feeders can be designed with the same voltage drop, or if this requires excessive copper in the longer

Appendix A.—Resistance of Street Railway Track with Electrically Brazed Bonds

	1,000 Feet Single Track, 2 Rails Bonded						
Rail size, lbs. per yd.	Rail resistance ohms per ft. without bonds.	Res. in ohms with 00 B & S bonds.	Cir. mills equiv. copper section at 25° C.	Amps. for 1 volt per 1,000 ft. gradient.	Res. in ohms. with 0000 B & S bonds.	Cir. mills equiv. copper section at 25° C.	Amps. for 1 volt per 1,000 ft. gradient.
50	20.10×10^{-6}	.01027	1.05×10^{6}	97.5	.01016	1.065×10^{6}	98.5
60	16.65×10^{-6}	.00854	1.265×10^{6}	117.0	.00844	1.28×10^{6}	118.5
70	14.39×10^{-6}	.00741	1.46×10^{6}	135.0	.00731	1.48×10^{6}	137.0
80	12.5×10^{-6}	.00647	1.67×10^{6}	155.0	.00637	1.70×10^{6}	157.0
90	11.36×10^{-6}	.00590	1.83×10^{6}	170.0	.00579	1.87×10^{6}	173.0
100	10.21×10^{-6}	.00532	2.03×10^{6}	188.0	.00522	2.07×10^{6}	192.0

feeders, several bus voltages may be maintained at the station.

The return system of a street railway is strictly analogous to any other D.C. network system of distribution and is subject to the same economical limitations controlling the design.

It may be said, therefore, that such a system should consist of a network of mains formed by the tracks with feeders connected thereto in sufficient numbers and properly located to keep the maximum voltage difference between any two points on the track system and the voltage gradient in the track within prescribed limits, while allowing such voltage drops in the feeders as consideration of power loss and cost of copper may dictate.

The above line of development will, however, be open to the consideration of using an increased number of substations instead of excessively long feeders, and the question itself becomes a further consideration of economic analysis with, however, the complicating condition of the advantages and disadvantages from an operating standpoint of an increased number of substations.

A number of electric railway systems, the growth of which resulted in the occurrence of electrolysis with the original layout, were able to return to satisfactory conditions for a period of several years by increasing the number of substations, but conditions have become again unsatisfactory, to the author's knowledge, due to further growth.

It is surely extraordinary that street railways, of all companies operating D.C. distributing network, should attempt to obtain close voltage regulation of their negative network by combining the function of main and feeder in one conductor, while experience in all other D.C. networks has shown the separate feeder and main system to be the only method capable of giving close regulation at anything but prohibitive cost.

THE MONTREAL AQUEDUCT PROJECT.

After a conference last week with the consulting engineers, Messrs. Vautelet, McRae, and St. Laurent, the Montreal Board of Control resolved to instruct Chief Engineer Mercier to prepare plans showing the modifications in the aqueduct scheme required according to the engineers' projects Nos. 2, 4 and 5. Controller Cote said, after the meeting, that when this information was available the board would be in a position to decide what project should be finally selected.

It was further resolved by the board to instruct the chief engineer to prepare specifications for the supply of electricity for pumping purposes. This is in accordance with project No. 5 of the report of the consulting engineers.

Controller Cote said that the quotations on electric power would be asked for periods of 10, 20 and 40 years. Personally he was in favor of adopting project No. 2, which is the present plan, with modifications.

Controller Cote further stated that during the discussion Mr. Vautelet declared that as regards the manufacture of artificial ice, as outlined in the report, with the surplus power of the city's plant in summer time, ice could be provided for a population of 1,500,000 persons if desired.

The United States supplied $536,354 worth or 80 per cent. of the total railway imports of Peru in 1915. The total value of the supplies imported was $664,103, the largest item of which was rails and accessories, $445,420.

THE DESIGN OF A TOWER FOR A 50,000-GALLON HEMISPHERICAL BOTTOM TANK.

(Continued from page 498.)

times the column stresses obtained from the diagram. This may be easily proved by taking moments about a line perpendicular to the direction of the wind. The maximum column wind stress is not the result of a constant load and occurs but rarely, so only 80 per cent. of it has been used in designing the columns.

With the total stresses in the tower determined we may now select the sections to be used for the various tower members.

Columns.—As the loads on the columns can be accurately determined and are only subject to gradual changes, it is permissible to use higher unit stresses than is customary in structures such as railroad bridges. For 10-inch channels, laced, give a maximum $\frac{L}{R}$, or slenderness ratio of 91, and unit stresses well within the allowable.

Rods.—One-inch diameter rods in each panel give unit stresses varying from 9,000 to 11,000 pounds per square inch.

Struts.—Struts are usually made heavy enough to carry erection equipment, and are much larger than is needed to provide for the wind stresses alone. The struts selected in the accompanying design will carry a load of 2,000 pounds at the centre in addition to the wind. The unit stresses due to wind are quite small.

Anchor Bolts.—When the tank is empty, the maximum wind load is sufficient to tip the structure over on two of its column bases. Anchor bolts are provided to prevent this. The net uplift is 14,300 pounds and it is taken care of by one 1¾-inch anchor bolt. Provision for rusting is made by selecting a large bolt with consequent low unit stress.

Foundations.—The maximum load under each foundation is equal to the sum of the maximum lower panel column loads plus the weight of the foundation. The foundation base should be large enough to distribute this load over the soil with a safe unit bearing pressure. Three thousand six hundred pounds per square foot is a conservative unit pressure to use with average soil conditions. The foundation should also be heavy enough to resist the maximum uplift, but except for small tanks on high towers, the uplift is usually not as great as the weight of the foundation.

When the members have been selected the weight of the structure can be calculated and the metal loads adjusted. This will probably not affect the design if the original metal loads were well chosen. We now have a design in which the stresses are fully known—one that we are sure will do the work for which it was intended.

We should not be too strongly influenced by designs of older structures. Because a tower has stood up in the past is no reason for believing that its design is faultless. Perhaps it is on the verge of failure, or, on the other hand, is far too heavy, and consequently uneconomical. With a good design the most is procured for the money expended.

In England and Wales there are 3,639 miles of canals; in Scotland, 183 miles, and in Ireland, 848 miles—a total for the United Kingdom of 4,670 miles, or 3,822 miles for Great Britain. Of the total mileage, 1,363 miles are owned by various railway companies.

RAILROAD DEVELOPMENT, COST AND WAGES

Government Railroads Compare Unfavorably with Private Enterprises in These Features.

The following memorandum has been issued by the Canadian Northern Railway:—

In the three cardinal features—development of country traversed, cost of service to the public and wages paid to employees—the state-owned railway systems, even those of Australasia, compare unfavorably with the privately owned railways of Canada and the United States.

The railways of North America give the cheapest railway service in the world and the wages of North American trainmen are the highest of which there is any record.

The only country with state-owned and operated railways to which economists point with any degree of assurance is Germany. The reasons for success there and the reasons presaging a lack of success in democracies, are given by Mr. W. M. Acworth, the British representative on the international board of inquiry into the Canadian railway situation, who, in speaking of the English railways, said recently:—

"Now, I am no foe of government railways. On the contrary, I believe that in countries with a population less self-reliant than our own, such a policy is necessary. In a country with a bureaucracy as well-trained and as well-organized as that of Prussia, it may even be desirable. Nay, more I am not concerned to deny that even here state purchase might do something to bring up the worst railway services more nearly to the level of the best. But a careful study of the evidence has convinced me that in the long run state control ends in keeping down the best to the level of the worst, and that, taking them all for all, the private railway companies of England and the United States have served the public better than the government railways of the continent, or of our Australian colonies, and which is still more to the point, are likely to serve it better in the future."

Germany and Canada.

The employees in 1913 on the railways of Germany numbered 786,466 and were paid, on the average $408.97 per year, 38 per cent. of the gross earnings. In Germany, all classes of freight considered, one and a third cents or 13 mills were collected for each ton of goods moved one mile.

In Canada during the fiscal year ended June 30, 1915,—the figures are used because they were those compiled from official records by the Bureau of Railway News and Statistics, Chicago—the employees numbered 124,142, who received on the average $727 per year, more than 45 per cent. of the gross earnings. Yet in Canada the railways collected only 7.51 mills, or about three-quarters of a cent for each ton of freight moved one mile. The rate charged in the United States for similar service in 1915 was 7.380 mills, or about ⅛ of a mill less per ton than in Canada.

In Australasia, where are established the only democracies constitutionally comparable with Canada, the railway situation is exceedingly complicated and the conditions—revenues collected and wages paid—vary in each division of the island continent.

Results in Australia.

New South Wales in 1914-15 had 4,057 miles of railway, and 24,515 employees exclusive of some 1,500 reported with the expeditionary forces. The state received 1.90 cents or nearly 20 mills for each ton of freight moved one mile (and in addition there are terminal receipts per ton of 23⅓ cents) and paid each employee on the average $741. Without counting in the terminal charges at all this 1.90 cents per ton per mile constitutes an increase of ⅛ of a cent upon the figures for 1914. The railways of New South Wales comprise the only standard gauge system in Australia.

Queensland in 1914-15 had 4,730 miles of railway of 3½-foot gauge. In addition there were some 400 miles of line in private hands and operated by local authorities and companies. The statistics do not say how much Queensland collects for each ton of freight, but this state pays to its 11,267 railway employees a little less than $650 per year.

South Australia in 1914-15 had 2,026 miles of railway, of which more than 1,100 were 3½-foot gauge and the remainder 5 feet 3 inches, in 1915. The employees numbered 10,182 and the average wages paid were $412.95 per year. The railways of South Australia charge 2.12 cents, or more than 20 mills for moving each ton of freight a mile, an increase of more than ¼ of a cent per ton upon the figures of 1914.

Western Australia in 1914-15 had 3,096 miles of railway entirely 3½-foot gauge. There were employed 8,148 persons and the average wages paid were $790.30 per year. In this system, also, it is not shown how much the railway collects for each ton of freight carried one mile.

Victoria in 1914-15 had 3,848 miles of railway, 122 miles of which is 2½-foot gauge and 3,726 miles 5 feet 3 in. The statistics do not show how much this state charges for moving freight, but point out that it pays its employees on the average $660.73 per year.

New Zealand in 1913-14 had 2,861 miles of railway entirely 3½-foot gauge. Employees numbered 14,176 and the average wage paid was $674.28. The statistics do not show the details of the revenues obtained for moving freight.

The wages paid on the Australasian systems vary, and the average for the six divisions is $654.76 compared with $727, the average paid in wages in Canada in 1915.

In Canada the enterprise of the railways has broken up the country into farms. In Australia there are ranches many thousands of square miles in extent, and the exports of wheat tell the story of the failure of the Australian railways to stimulate general farming activities.

TO BUILD STEEL SHIPS.

Mr. R. P. Butchart and Captain J. W. Troup, director and assistant director, respectively, for the Imperial Munitions Board for British Columbia, on their return to the Pacific coast from Ottawa, where they were in consultation with the Imperial Munitions Board in regard to the construction of wooden steamships, made the following statement:—

"The Imperial Munitions Board has decided upon the building in Canada of a standard type of vessel, 250 feet long, 43 feet 6 inches beam and 25 feet deep, with a deadweight capacity of about 2,800 tons on a draft of 21 feet. The vessels are to be built very strongly, with box girder stelsons. They have a deep tank forward for water ballast. They are to be propelled by steam, with triple expansion engines of about 950 indicated horse-power. The matter of geared turbines from England is being considered for some of the ships. The vessels are to be built of Douglas fir to Lloyd's requirements for A1 classification.

"The authorities are in favor of concentrating on steel shipbuilding in Canada rather than on wooden ships, it being considered preferable to build boats of steel construction."

Mr. Butchart and Captain Troup have placed the facilities of British Columbia before the board, and as soon as they have an opportunity of lining up the situation in British Columbia they will report to the board as to the building that could be undertaken there. The programme that has so far been outlined is not extensive. It remains to be seen what facilities and what inducements British Columbia can offer to the authorities.

C.N.R. EMPLOYEES SIGN PETITION.

Employees of the Canadian Northern Railway presented a memorial to the Prime Minister last week, protesting "in the strongest terms possible against putting into effect of the majority report of the Royal Commission," which investigated the Canadian railway situation. The memorial was from conductors, engineers, trainmen and firemen. It opposes the nationalization of the Canadian Northern and Grand Trunk systems, and urges that Government operation of a railroad by commission or otherwise free from political influences is practically impossible. It quotes with approval the conclusions of the minority report, made by A. H. Smith, "the only practical American railway man on the Royal Commission." In conclusion it contends that if the Canadian Northern is given some further assistance, especially to secure equipment, the company will be able to work out its own salvation.

LESS THAN ONE-THIRD STATE-OWNED

That is Record of World's 700,000 Miles of Railways—Evidence of W. M. Acworth

While it was true that "most countries own their own railways," the statement is misleading, said Mr. W. M. Acworth, the English railroad authority, in giving evidence before a special meeting of the Joint Committee of Congress on Inter-State Commerce. Mr. Acworth, with Sir Henry Drayton, signed the majority report of the Royal Commission, which investigated the Canadian railway situation. Bulgaria, for illustration, owns its railways, which comprise only 1,204 miles. Bulgaria counts as one country, and so does the United States. But the United States has more than 200 times the Bulgarian mileage, all owned privately. Accordingly, on a mileage basis, the witness pointed out, less than one-third of the world's 700,000 miles of railways is owned by states. Mr. Acworth dealt first with Prussia, which he regarded as the best example of an efficient nationalized railway system. Following the war of 1870, which unified Germany under the leadership of Prussia, Bismarck attempted to acquire all the railways of Germany in order to weld the newly formed empire into one unit. In 1879, the ministry submitted to the Prussian parliament an elaborate memorandum in support of the policy of nationalizing the railroads then in private hands. The significant feature of this memorandum, said Mr. Acworth, was the emphasis placed upon the importance of railways for military purposes. "On the whole," said he, "it is abundantly clear that the main reason for Bismarck's action was of a political nature. It is in harmony with all Prussian history that the importance of military considerations and the necessity of making public control paramount in the life of the country should weigh above all other considerations with a Prussian statesman; and after the war with France and the creation of the German empire, these considerations might be expected to have even greater weight than at any other time."

Old Equipment and Methods.

Citing Professor Schumacher, of Bonn, Mr. Acworth said that the freight receipts per ton mile in 1880 and 1909 in Germany were respectively 1.65 and 1.41 cents. The corresponding receipts per ton-mile for American railways were, in 1882, 1.23 cents, and in 1909, 0.763 cents. In other words, the American ton-mile rate started at the beginning of the period 25 per cent. below the Prussian rate, and it fell in the course of the 29 years, not 15 per cent., but nearly 40 per cent. At the end of the period, the American rate was not much more than one-half the Prussian rate—0.763 cents compared with 1.41 cents. The witness added that progressive rate reductions in Germany had ceased long before 1909. Proceeding he said:—

"While American companies have revolutionized their equipment and methods of operation, Prussia has clung to old equipment and old methods. This is typical. In all the history of railway development it has been the private companies that have led the way, the state systems that have brought up the rear. Railroading is a progressive science. New ideas lead to new inventions, to new plant and methods. This means the spending of much new capital. The state official mistrusts ideas, pours cold water on new inventions and grudges new expenditure. In practical operation, German railway officials have taught the railway world nothing. It would be difficult to point to a single important invention or improvement the introduction of which the world owes to a state railway. That Prussia is the only country where the state system shows a profit after payment of operating expenses and interest on capital follows because Prussia bought the railroads at a most opportune moment, and has been powerful enough to maintain a scale of rates unaltered over a long period of years. When it comes to railroad tariffs, no country has gone as far as Prussia in giving advantage to the big shipper over the small man."

State Ownership in Italy.

Referring to Italy, Mr. Acworth said: "It has tried state ownership and operation, private ownership and operation, state ownership with private operation, and now, for the last ten years, it has reverted to both ownership and operation by the state." The Italian parliament on April 22, 1905, determined to take over the railways of Italy. In the first year of nationalization the operating ratio was 73.4; in no subsequent year has it fallen below 79.5, and for the three years, 1911-1913, it averaged 84.4 Each year shows a substantial advance in operating costs over the year preceding it. The figure in the first year of the period was $57,885,600; in the last it is $102,264,560, an increase of over 78 per cent. He continued:—

"The final result is that whereas in the financial year 1906-07 the railways paid over to the treasury $9,796,366 as a return on a capital of $1,091,404,045, which is roughly, 1 per cent., in the last year they only returned $5,402,656 on a capital that meanwhile had risen to $1,374,975,952, which is, roughly, two-fifths of 1 per cent. In at least two cases just before the war, concessions had been granted to a private enterprise which was to take over a portion of the existing state railway, to build an extension with the help of a substantial state subsidies, and then work on its own account both sections as one undertaking.

"Australia furnishes the most conspicuous instance of railway construction by the state, because private enterprise refused to undertake the task. Speaking broadly, the seven separate states which make up Australia have 20,000 miles of railway owned and worked by the respective governments. And it must be frankly said that public opinion is entirely in favor of the system. Having regard to the well-known fact that state socialism has been carried further in Australia than in any other part of the world, this is not surprising."

Australian Rates Excessive.

Ton-mile rates on the state railroads in Australia are excessive compared with other countries, said the witness. In two states they average 2.20 and 2.12 per ton-mile. The corresponding private railroad rate in Canada is only 0.75 cent and in the United States 0.73 cent. A mixed system of state and private ownership prevails in Russia, Austria and India, owing mainly to political and military reasons. Referring specifically to one company, which had paid an average dividend of 12 per cent. for five years previous to its acquisition by the Austrian government, Mr. Acworth quoted the president of the Austrian chamber of deputies in describing the result of the state's administration up to 1910. Said that official:—

"We have always been in favor of the state taking over the railways, but if we had been able to foresee the results of the management, I assure you we would have hesitated a little longer. We are still in favor of the principle, but it does seem to us that our government has performed a remarkable feat when it has succeeded in creating a deficit on the Northern Railway. The government have enlisted an army of new employees; they have gone much too far in the reduction of hours of labor; instead of commercial management, they have appointed lawyers to posts that require business men or experts; they have established an entirely unpractical bureaucracy. At the present moment we are face to face with a deficit of $25,000,000. There would be no deficit at all if the return from our railways were that which it ought to be. I repeat that absolute imbecility has characterized the taking over of our railways. We must introduce business ideas into the government service."

Private Railways in Russia.

Of late years in Russia the tendency seems to be in the direction of private railroad enterprise, subsidized and closely controlled by the government. Continuing, Mr. Acworth said:—

"While in Holland some of the most important lines were built by the state, the operation has always been wholly in private hands. In 1908 a motion in parliament in favor of nationalization was brought forward and defeated. A parliamentary commission to investigate the question was subsequently appointed and reported unfavorably. The financial result to the state is not over satisfactory, but is due largely to the competition of the rivers and canals, which intersect the country. The railways have to depend mainly on passengers and high-class freight for their income.

"For more than 30 years the French government have owned and worked a system of lines in the central west of France. The financial results were very unsatisfactory—the operating ratio over a series of years ranged between 72 and 83 per cent. Among the great companies much the weakest financially is the Western. Year after year the French government had to find a considerable portion of the dividend for this road. During the last ten years of company manage-

ment the state had to pay an average of $2,894,280 a year to meet its liability under the dividend guarantee. During the first three years after the transfer of this road to the government, the latter had to pay $6,753,320, $8,875,792 and $14,934,484, respectively. For the year 1913 the figure was $14,752,237."

Moreover, the service to the public was absolutely demoralized, and compensation for accidents, loss and damage rose from an average of $400,000 under company rule to $2,045,291 in 1911. The minister of public works criticized the state administration as a "frightful fraud," said Mr. Acworth, and the senate passed a resolution referring to "the deplorable situation of the state system, the insecurity and irregularity of its workings."

In 1897 Switzerland took over all the railways of the country. Immediately an increase in expenses was noted, due to higher wages and reduced working hours. In three years, after meeting operating expenses and the charges of the debt, there was an accumulated deficit of over $2,500.000. In 1900 the ton-mile rate was slightly under 3 cents a mile; in 1911 it was slightly over. At the date of the last account, so far from being reduced, the sum paid for the acquisition of the railways had risen $270,000.

CANADIAN DES MOINES STEEL CO., LIMITED.

The Pittsburgh-Des Moines Steel Co., of Pittsburgh, Pa., and Des Moines, Iowa, has purchased the property of the Chatham Bridge Co., 298 Inches Ave., Chatham, Ont., and has incorporated the Canadian-Des Moines Steel Co., Ltd.

The Chatham plant has been enlarged and completely equipped to handle all standard types of steel structures, including mill buildings, office buildings, fire escapes and bridges. The company will make a specialty here, as in the United States, of the manufacture and erection of elevated steel tanks for municipal, industrial and railway service, and other special structures such as standpipes, storage tanks, smoke stacks, barges and coaling stations.

The risers of the elevated tanks are enclosed in wooden frost cases and the water is prevented from freezing by a steam coil in the tank or by a special heater which takes water from the base of the riser and heats it and delivers it through a separate pipe into the tank. This method of heating may utilize exhaust steam from a power plant.

Another specialty of the company in the United States has been the manufacture of wireless telegraph towers. Towers from 100 ft. to 600 ft. high have been built for the United States Government at various stations.

All steel for delivery in Canada will be fabricated at the Chatham plant, and all sales will also be handled from Chatham.

NIAGARA FALLS POWER COMPANY.

The annual report of the Niagara Falls Power Company states that all permitted means have been taken to meet the rapidly increasing demand for power. Two additional generating units in the Canadian plant have been completed and placed in service. A third unit is now in process of being added. The management points out that the rapid increase in power use in Canada has led the government considerably to reduce its permits for the exportation of Niagara power, and adds: "The export license of our Canadian company has been reduced from 75,000 horse-power to 30,000 horse-power. We have, therefore, been obliged to withdraw 45,000 horse-power from United States industries, despite insistent demands."

In Alpena, Mich., the death rate from typhoid fever ranged from 30 to 95 per hundred thousand population, each year from 1900 to November, 1915, when a liquid chlorine plant was installed. In the first twelve months of operation of the chlorinator there were only 11 cases of typhoid fever and only one death, and of these cases it was known that at least five were contracted outside of the city. Instructions to the people to boil the water had not been regarded sufficiently by all the people, and sterilization of the whole supply was found to be the only positive safeguard.

HERRON BROS. vs. CANADIAN STEWART CO.

In *The Canadian Engineer* of May 24, 1917, it was stated that Justice Masten had given judgment in favor of the plaintiffs in the suit of Herron Bros. vs. Canadian Stewart Co. to recover 90 per cent. of the price of piles said to be delivered to the defendant. That item was copied from Toronto daily newspapers, there being no reason to doubt its accuracy. The Canadian Stewart Co. have subsequently afforded *The Canadian Engineer* an opportunity to read the full judgment, however, and it is desired to correct the previous item, as from the judgment it appears that no amount was awarded to Herron Bros., but that a declaration was made that the plaintiffs might make reference to a master regarding the accounts between themselves and the defendants generally and on the questions raised by the defendants' counterclaim; the master to report specially as to whether the piles or any of them which were rejected in August, September and October, 1915, by the Department of Public Works, were so rejected in consequence of defects existing at the date of delivery to the defendants or whether they were rejected in consequence of deterioration which arose after delivery.

Justice Masten's judgment concludes as follows: "The defendants (the Canadian Stewart Co.) succeed on the main issue now before me and are entitled to costs down to and including the trial, but excluding any cost of the issue relative to the agreement of March 31st, 1916. If a reference is taken, further directions and costs subsequent to the trial are reserved."

Herron Bros. wrote to the Canadian Stewart Co. on November 14th, 1914, saying: "We quite realize under the conditions of our contract that we have to replace any piles that have been culled or may be culled by the government engineer or his inspectors, and we have not the slightest inclination to avoid any responsibility in the matter—all we ask is fair treatment."

In his summing up, Justice Masten says: "We have no written repudiation or limitation by the plaintiffs of the letter of November 14th, 1914, until after the catastrophe in July, 1915. But I am of the opinion that upon receipt by the defendants of the piles when unloaded at the cars, the property in the piles passed to the defendants, and the piles were then in their custody and at their risk so that they are chargeable with any subsequent deterioration, but subject always to defendants' right to return any pile and require it replaced if subsequently rejected by the government engineer in consequence of defects existing at the time of its delivery by the plaintiffs to defendants."

CANADIAN CAR AND FOUNDRY COMPANY.

The statement of the Canadian Car & Foundry Co., covering the year ending Sept. 30th, 1916, it is understood in Montreal circles, will not show any results from the Russian contracts, as at that date the business was not completed, but at the annual meeting, in July, the management will be in a position to give the shareholders full particulars as to the profits made on the Russian business. The statement to be issued covers the Canadian business and it is intimated that profits, after bond interest and depreciation, will be around $375,000.

PROTECTING THE WATER SUPPLY.

The beneficial effect of proper supervision, and particularly of maintaining forest growth, in waterworks catchment areas, is being more fully recognized. A recent example is in the state of Pennsylvania, where the Commissioner of Forestry urged the planting of trees on those portions of their waterworks catchment areas not useful for agriculture. Favorable replies were received from one-half and, of the remainder, over 100 had no land requiring planting. To those who replied favorably, all planting facilities were afforded, including the services of a forester, and seedlings were offered at bare cost of packing and shipping, about 50 cents per 1,000 seedlings delivered. Applications were made for a total of 446,100 young trees for use on about 230 acres.—(By Leo G. Denis, in "Conservation.")

Editorials

CANADIAN SOCIETY OF CIVIL ENGINEERS IN THE MARITIME PROVINCES.

In 1887 the Canadian Society of Civil Engineers was established in Montreal, but no branches of the society were organized for eighteen years, or until 1905, when the first branch was founded in Sydney, N.S., with fourteen members.

Geo. H. Duggan, general manager of the Dominion Bridge Co., and immediate past president of the society, was one of the active organizers of the branch at that time. Those were booming times in the Nova Scotia steel and mining industries, however, and the branch survived only one year, business apparently having too great a demand upon the members' time for them to be able to devote any attention to the society meetings.

In 1906 the Toronto Branch was organized, and this was rapidly followed by others from Quebec to Victoria, so that there are now ten branches of the society, with a total branch membership of approximately one thousand. However, the Maritime Provinces, where the branch idea started, remains without a branch, as there is no such organization east of Quebec.

Mr. Duggan's presidential address, read before the society last January, showed that there were 252 corporate members (members or associate members) in the district east of Montreal, or 11.9 per cent. of the total corporate membership of the society. An analysis of the 1916 list of members shows that there are 138 corporate members, or approximately 6.6 per cent. of the corporate membership of the society, resident in the Maritime Provinces or Newfoundland.

It is obvious that there should be a branch of the Canadian Society of Civil Engineers in the Maritime Provinces, not only on account of the number of members living there, but more especially on account of the very great importance of the big engineering industries in those provinces. A live branch would no doubt attract some of the many engineers working in the Maritime Provinces who are not as yet affiliated with the society. *The Canadian Engineer* understands that E. G. Horne, A.M.Can.Soc.C.E., of St. John, N.B., is endeavoring to establish a branch at either St. John or Halifax, or possibly a joint St. John-Halifax branch, and it is to be hoped that all members of the society will give their earnest support to Mr. Horne and those associated with him in the effort.

POLITICS UBER ALLES!

Politics appears to have the upper hand of patriotism at Ottawa. Despite the railway situation and the many other problems which require urgent attention, it seems that parliament is about to dissolve and to plunge the country into the throes of an election.

Sir Wilfrid Laurier blames Sir Robert Borden for the failure of attempts at coalition, and Sir Robert places the blame upon Sir Wilfrid's shoulders. The average engineer, contractor or business man in general will be inclined to blame both of them for not sacrificing their own and party interests to a sufficient extent that all outstanding differences be settled by some means.

England early found the necessity of a national government in time of war, but Canada, after nearly three years of war, has yet to learn how to forget party politics and fight shoulder to shoulder.

Next to the war, the most important matter before parliament is the railway problem. The delay which must necessarily ensue in the settlement of this problem will not be to the benefit of the shippers of Canada or of the people generally. Apparently there will be no parliamentary relief during the coming winter for the freight congestion troubles.

The system upon which our government is founded does not very well admit of a third party. The whole working of the government is based upon the assumption of a two-party House of Commons. Were it not for this, the business men of the country no doubt would be strongly tempted to organize a third party to take part in the coming election—a National Party which would appoint lawyers to legal positions, business men for business executive jobs, and engineers where engineering executive work is required.

BUSINESS IN QUEBEC

A number of Canadian firms seem to recognize the value of the French language as an aid to developing trade with Quebec province. Aside from racial and political considerations, many firms in Ontario and elsewhere tell *The Canadian Engineer* that their business has greatly increased as a result of printing their catalogues and circulars in the French language for circulation in that section of the country. Instances are known where letters in English have been thrown away by the recipients without any effort to ascertain their contents; the same applies to catalogues and other advertising matter printed in English. An inquiry recently made by *The Canadian Engineer* yields the general opinion that as there are many country districts in the province where French is practically the only language spoken, it is obvious that the use of the French language should be a factor in increasing sales there.

An Ontario correspondent relates his business experiences in Quebec and points out that to get the best results in doing business anywhere, one must speak the language that is best understood. For that reason, it is well that the language of the country into which a person goes to do business should be known by him. Besides a knowledge of the language, it is well to have some knowledge of the habits, customs and characteristics of the people. Personality also has a strong influence in doing business. Some interesting opinions on this subject were received.

It is often said that French-Canadians do not speak the "genuine Parisian French." According to Mr. Leon Lorrain, secretary of the Montreal Chamber of Commerce, there is not such a thing as Parisian French. "In Paris, Montreal, Quebec or any other French-speaking centre," he says, "people speak more or less correctly according to the education they have received; but they speak French. In a parallel case, the English language, though spoken with a different accent in each country, is still the English language, understood by all."

PERSONALS.

REGINALD H. BALFOUR, B.A.Sc., has been appointed sales manager of the Eugene F. Phillips Electrical Works, Ltd., Montreal. Mr. Balfour is a graduate of McGill University and an associate member of the Canadian Society of Civil Engineers. He was formerly engineer for the Montreal Electrical Commission.

JAMES B. BEGG, road superintendent of Victoria County, Ont., has resigned.

MARCEL C. J. BEULLAC, B.Sc., M.Can.Soc.C.E., who has been an officer in the French army for the past two and a half years, has been invalided home and has rejoined the city contracting office of the Dominion Bridge Co. at Montreal.

W. M. BREWER was elected chairman of the Western Branch of the Canadian Mining Institute at its recent meeting held in Victoria, B.C.

LAWFORD GRANT has been appointed managing-director and treasurer of the Eugene F. Phillips Electrical Works, Ltd., Montreal. Mr. Grant came to Canada in 1907 as president and managing-director of the Canadian British Insulated Co., Ltd. In 1913 he accepted a position as assistant manager of the Phillips Company, and now succeeds Geo. H. Olney, who was the head of that firm for eighteen years, Mr. Olney having recently retired owing to ill health. Mr. Grant is a civil and electrical engineer, and was formerly engineer for the British Insulated & Helsby Cables, Ltd., of England. Among the many large undertakings which he carried out for the latter company was the electrification of the government dock yard and naval base at Malta. The Phillips plant is in size among the first half-dozen of the insulated wire and cable works on this continent.

M. DONALDSON, M.Can.Soc.C.E., vice-president and general manager of the Grand Trunk Pacific Railway Company, is reported to be seriously ill in a Montreal hospital.

Capt. A. DOUGLAS FISKEN, reported wounded and gassed, was educated at Trinity College School at Port Hope and at the Military College, Kingston. After graduating in 1910, he was employed as an engineer in New York City until war broke out, when he returned to join the Canadian forces.

Flight-Lieut. O. J. GAGNIER, reported wounded, graduated with the 1917 class in applied science in civil engineering at McGill University. He took his preliminary course at Long Branch, Ont., last year, then went overseas to join the Royal Naval Air Service.

W. H. BREITHAUPT, M.Can.Soc.C.E., has been elected chairman of the new town-planning commission at Kitchener, Ont. NORMAN C. HELMUTH was appointed as secretary.

JOHN D. GALLOWAY, assistant mineralogist, Department of Mines, Victoria, B.C., has been appointed engineer for the Northeastern Mineral Survey district with headquarters at Hazelton. Mr. Galloway is a graduate of McGill University.

WM. WREN HAY, Jr. Can. Soc. C.E., is now in training at Camp Funston, Texas, having been examined and recommended for commission in the Engineer Reserve Officers Corps, United States Army, as first lieutenant. Mr. Hay has been for two years on duty in the office of the Department Engineer, Southern Department, at Fort Sam Houston and El Paso, Texas.

ED. HOLGATE, of the engineering staff of the Structural Steel Co., Limited, Montreal, has joined the engineering staff of MacKinnon, Holmes & Co., Limited, of Sherbrooke, Que.

J. A. JAMIESON, a well-known consulting engineer of Montreal, who was very badly injured some time ago in a street accident, is recovering nicely although still confined to his home.

HOWARD KELLY, vice-president of the Grand Trunk Railway Company, has been appointed acting president, E. J. CHAMBERLIN, president, having been granted leave of absence.

Lieut. W. G. McGHIE, a graduate of the Faculty of Applied Science and Engineering, University of Toronto, class 1911, has been awarded a medal by the Italian government for bravery. Lieut. McGhie was formerly with the Canadian Crocker-Wheeler Company, St. Catharines, Ont., and went to France with the 35th Battalion.

Capt. F. H. MOODY, formerly editor of "Canadian Railway and Marine World," Toronto, has been reported wounded on May 26th. He is a graduate of the School of Practical Science, Toronto, and a junior member of the Canadian Society of Civil Engineers. He went overseas last summer with an Ontario county battalion as major, but reverted in order to get to France.

Lieut.-Col. STRATTON H. OSLER, of Cobourg, Ont., has been awarded the Distinguished Service Order by the British War Office. Col. Osler attended the Royal Military College at Kingston and also McGill University, where he took a course in engineering. He went overseas with the Royal Canadian Engineers in command of a company in the 2nd Canadian Division and was promoted on the field to lieutenant-colonel for his efficient work.

Lieut. WILLIAM B. PENNOCK, a graduate in Civil Engineering of McGill University, class 1915, is reported wounded. After securing his degree, Lieut. Pennock qualified for a commission at Ottawa and, after reaching the front, was posted to a field company of engineers. Some months ago Lieut. Pennock was mentioned for bravery and it was reported that he had been recommended for the Victoria Cross in recognition of his gallantry. His home is in Ottawa.

T. E. PRICE, A.M.Can.Soc.C.E., for the past five years resident engineer on the Vancouver division of the Canadian Pacific Railway, has joined the Railway Construction Corps and has been given a commission as lieutenant. He is a graduate of McGill University.

Hon. ROBERT ROGERS, minister of Public Works, Federal Government, has been relieved of his duties at his own request, pending the report of the commission appointed to investigate the Galt findings.

Pte. ROBERT JOHN THOMPSON, who was a student of the School of Practical Science at the time of enlistment, and who was wounded last September, was again wounded by gunshot in the face recently. He is 20

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

KITCHENER SEWAGE DISPOSAL WORKS

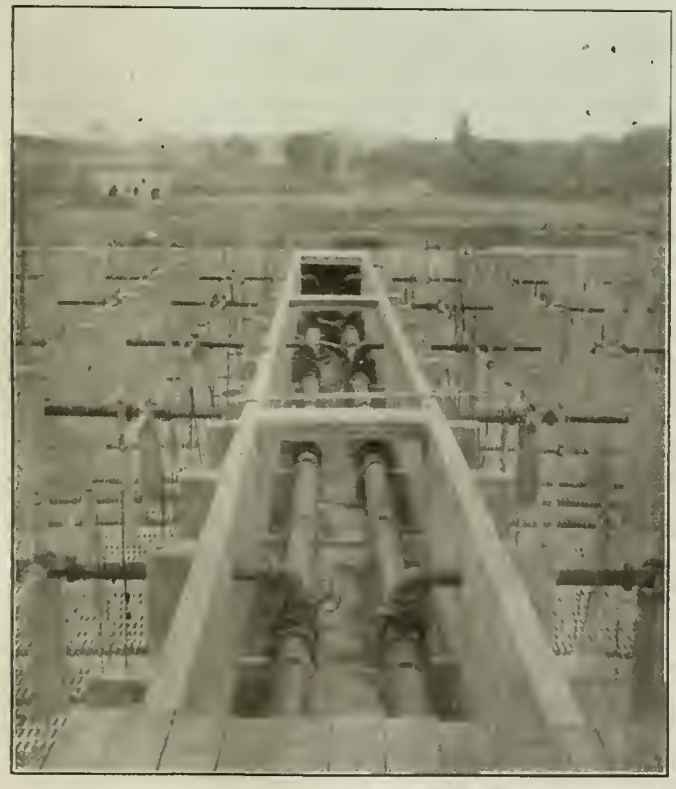
City Will Have Two Complete Disposal Systems of Different Types—New Two-Story Type Sedimentation Tanks and Spraying Filters Now Being Constructed at Cost of Approximately $75,000

By HERBERT JOHNSTON, A.M.Can.Soc.C.E.
Formerly City Engineer, Kitchener, Ontario

KITCHENER'S sewerage system was commenced in the year 1891 by the town engineer, the late H. J. Bowman. The first sewage disposal works were constructed shortly afterwards. A means of disposal was necessary at once, as the only outlet for the sewage was into a small creek with a dry-weather flow of about 1,000,000 gallons per day.

Kitchener grew rapidly from a small town with a population of 7,500 in 1891 to a city of over 19,000 in 1915. It has become a factory centre with over one hundred and twenty factories, including two large tanneries, three felt factories and three large rubber factories. The effluents from the factories make the sewage much more difficult to treat than ordinary domestic sewage.

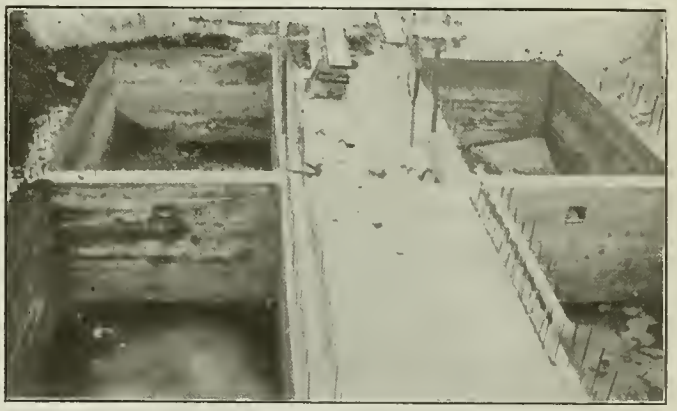
The following table gives an idea of the increase in the amount of sewage in comparison with the increase in population. The extensions in the sewer system has been much more rapid during the last few years, and the number and size of the factories have also grown rapidly.



Filters, Showing Pipe Gallery.

Year.	Population.	Gals. of sewage.
1891	7,500	.....
1899	9,360	225,000
1901	9,900	327,000
1903	10,400	414,000
1906	12,150	668,000
1915	19,300	1,300,000

Kitchener has adopted the separate system, and storm water is kept out of the sewers so far as possible, in order to keep at a minimum the amount of sewage to be treated.



Sedimentation Tanks, Showing Lower Sections.

In the year 1896 the town had outgrown its first disposal works, as complaints were made by the farmers along the creek. These complaints were investigated by the provincial board of health and the creek found to be badly contaminated. As the town did not improve its disposal works these same farmers sued the town for damages, about 1900 and 1901, and they received large amounts as compensation.

In 1902 the provincial government was asked to help the town solve its sewage problem, and the government sent Dr. J. A. Amyot to investigate. The result of Dr. Amyot's report was that a new sewage plant was installed in 1904-1905 under the supervision of Wm. Mahlon Davis, who was then town engineer and the writer's partner.

This consisted of:—

1.—Two septic tanks with a capacity of 450,000 gallons.

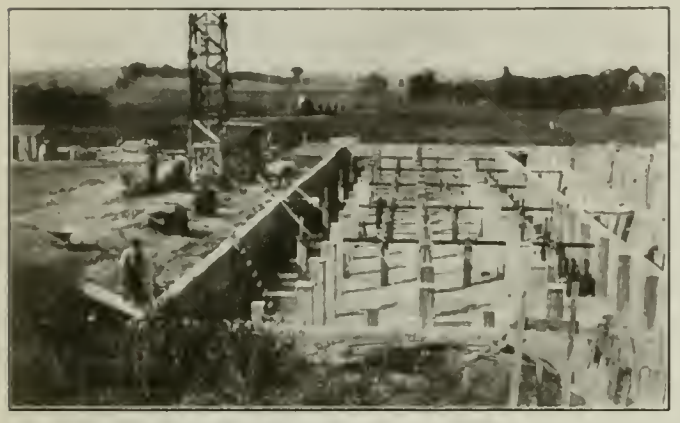
2.—Two storage tanks with a capacity of 450,000 gallons.

3.—Pumping station and pumping machinery, consisting of two turbine pumps with a capacity of 1,000

gallons per minute each; two 60-h.p. motors; and one sludge pump with a capacity of 500 gallons per minute.

4.—Sixteen natural sand filtration beds, containing 14 acres of filtering area.

This system gave excellent results, giving off an odorless effluent as clear and sparkling as spring water. It is still giving these results to-day.



General Interior View of Filters.

In 1911 the amount of sewage was beyond its capacity and the writer, as city engineer, recommended its extension. The sewerage commission asked the city council for the money. Owing to other difficulties between the council and the commission, the work was taken over by the council and the commission was dispensed with.

Nothing more was done until 1914, when the farmers again complained of sewage going into the creek. The area of the beds was then extended to twenty acres. This was still insufficient to take care of all the sewage, so the provincial board of health was interviewed by the sewer committee. The board recommended that either the present system be extended or that deep two-story sedimentation tanks and a spraying system be constructed.

As all the available land suitable for filtering purposes on the present farm had been used, and as it was uncertain whether the spraying system of filters would give an effluent pure enough to discharge into the creek,

Sedimentation Tanks.

owing to the factory wastes in the sewage, it was decided to call in Willis Chipman, of Toronto, as consulting engineer to solve the problem.

The writer suggested extending the trunk sewer down the creek to the Grand River about two and a half miles, and adopting the deep sedimentation tank and spraying filters. This would give plenty of head to operate the plant by gravity, while at the present works all the sewage has to be pumped. Also, it would not require so many for its operation, and the effluent would be diluted by a much larger stream of water, and all trouble with the farmers would be overcome. As the present farm is partly in the city, it could be sold later at a good price. This was not adopted as the initial expense was considered too high.

Mr. Chipman recommended:—

1.—That, as the city has two main trunk sewers, an 18-inch pipe and a 48-inch pipe, that the domestic sewage be diverted to the 18-inch sewer and the factory sewage into the 48-inch sewer and the old system of septic tanks and sand filters be used to treat the sewage from the 48-inch sewer.

2.—That sedimentation tanks of the two-story type be constructed with a capacity of 500,000 gallons per twenty-four hours for the treatment of the domestic sewage, conveyed by the 18-inch sewer.

3.—That two spraying filters be constructed to treat the effluent from these tanks.

4.—That two small humus tanks be constructed to remove the suspended matter.

Sedimentation Tanks, Showing Aprons.

5.—That sludge beds be constructed for drying the sludge from the sedimentation tanks.

6.—That a pumping plant be installed.

He gave the following reasons for recommending these:—

1.—Small area of land required and no expenditure for additional land.

2.—Extensions possible to 2,000,000 gallons per day without material changes.

3.—Better results in winter months than with beds.

4.—Sludge nuisance practically eliminated.

5.—Old works and new works together, cost of maintenance and operation therefore reduced.

6.—The new system will produce a satisfactory effluent in winter and in summer.

This report was adopted and the contract for the work was let in September, 1915. The new plant consists of the following:—

Diversion Chamber.

The diversion chamber consists of a concrete building in which are the screens and valves controlling the flow of the sewage. From the 48-inch sewer the factory sewage runs to the old septic tanks. From the 18-inch

sewer the domestic sewage enters a cast-iron suction pipe which leads to the new pumps in the pumping station.

Pumping Station.

The old pumping station was built of concrete. A concrete addition has been added in which is placed the pumping machinery for the new plant.

Pumping Machinery.

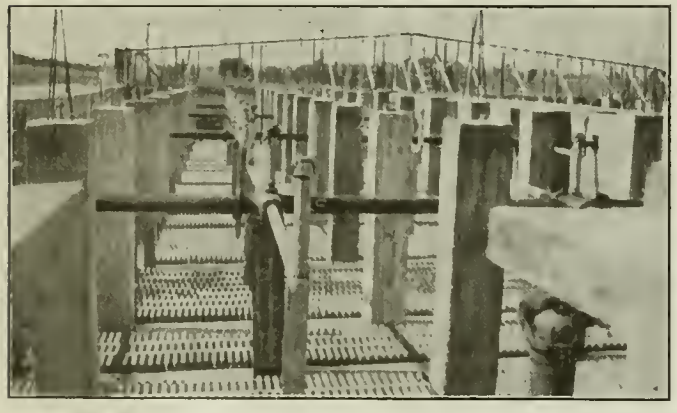
The pumping machinery consists of the following:—

1.—Two turbine pumps, each having a capacity of 500 Imperial gallons of sewage per minute against a head of 33 feet.

2.—Two electric motors with a capacity of 25 h.p. each.

3.—One Venturi meter tube with 4-inch throat designed to measure from 300 gallons to 1,200 gallons per minute. It is furnished with a register, indicator-recorder. The chart recorder dial shows the rate of flow in millions of gallons per day. The register shows the total Imperial gallons pumped and the indicator dial shows the rate of flow in gallons per minute.

4.—The switchboard consists of three panels, 65 ins. x 25 ins. x 2 ins., of black marine slate. It is furnished with two ammeters, one volt meter, one Westinghouse integrating wattmeter and a recording meter.



Interior of Filters, Showing Brick, Piers, Piping and Forms for Siphon and Dosing Chambers.

Sedimentation Tanks.

There are two sedimentation tanks of the two-story type, 55 ft. by 21 ft. x 26 ft. deep. They are placed side by side. The distributing channels and valves are so arranged that the sewage may be made to pass through only one or through both tanks at once.

The piping is arranged so that the sludge may be drawn off by gravity. A passage is provided for raking the scum off the top. The tanks are covered with removable planks. These tanks have been completed and are now in operation.

Spraying Filters.

The spraying filters are built in two sections, each 180 ft. by 40 ft. Between the sections is a gallery 7 ft. wide, in which the supply pipes and valves are placed. Each section is fed by a syphon chamber and a dosing chamber.

A reversible screen chamber is placed between the syphon chamber and the sedimentation tanks. This is furnished with fine screens to remove any solids that may pass through the tanks.

The effluent from the filters is carried away by channels made in the concrete floor to each side and then along the outside walls to pipes leading to the humus tanks. These channels are covered with concrete bricks laid with open spaces so as to allow the effluent to pass through. These bricks support seven feet of broken stone which make up the filtering media. The lower course consists of 3-inch and 4-inch stones, one foot in depth; the next course, 2-inch and 3-inch stone, five feet in depth;

Filters After Construction of Roof.

and the upper course, 1-inch and 2-inch stones, one foot in depth.

The filters will be enclosed with concrete walls with a concrete roof.

Humus Tanks.

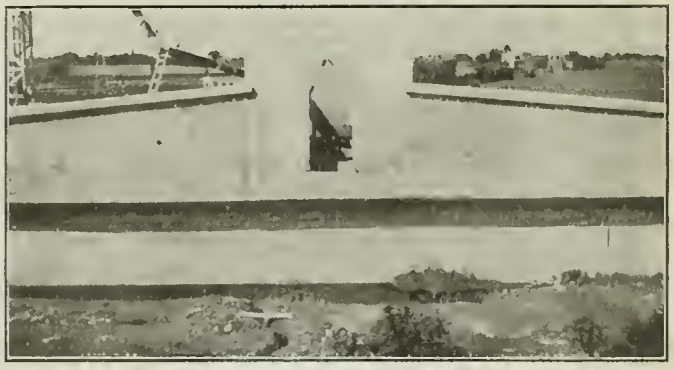
The humus tanks will be 19 ft. in diameter and 16 ft. deep. The effluent will enter through a pipe in the centre and pass out over a weir running all around the outside. From the humus tanks the effluent will pass to the creek.

Sludge Beds.

There are two sludge beds, 100 ft. by 70 ft. The natural sandy soil was graded and banks constructed. Four-inch field tile were placed under the beds 4 ft. apart, with 6-inch cross tiles 20 ft. apart. The sludge from the sedimentation tanks will be conveyed to these beds by gravity through a 12-inch cast-iron pipe.

There is also a small sludge bed, 50 ft. square, to dry the sludge from the humus tanks. This sludge will be conveyed to the bed by gravity.

The cost of the whole work will amount to about



End View of Filters, Covered.

$75,000, which includes about $7,000 for diverting the factory sewage to the 48-inch sewer and laying a water main to the spraying filters for flushing purposes.

G. B. Moogk, of Weston, is the contractor; Marcel Pequegnat, the resident engineer. The pumping machinery was installed by the Canadian Allis-Chalmers Co., Ltd.,

Pumping Station.

of Toronto, and it is now in operation. The whole contract was to have been completed by July 1st, 1916, but owing to the scarcity of labor it is not yet complete, but it should be in a few months.

Kitchener will now have two complete systems of sewage disposal works of different types.

C.M.A. OPPOSES NATIONALIZATION.

The Canadian Manufacturers' Association is opposed to the plan for nationalization of all Canadian railways (except the C.P.R.) as proposed by Sir Henry Drayton and Mr. Acworth. It offers as a substitute the following suggestion, carried last week at its annual meeting in Winnipeg, and sent to Ottawa:—

"(1) That immediate steps be taken to assist in overcoming the desperate need for equipment, which at present exists, by providing an ample supply of cars and locomotives and turning them over to the companies under lease or contract of purchase;

"(2) That a Board of Trustees be appointed to receive all moneys of the companies unable to meet their obligations, and to determine and supervise all expenditures of the railways to whom advances might have to be made."

C. B. Watts, of Toronto, was a strong advocate of nationalization, but he got little support.

C. B. Hamilton, also of Toronto, proposed that as a war-time measure a central board of the ablest railway men available should be created to operate the railways as efficiently as possible, as a National Service system, but his amendment was defeated. George H. Douglas, of Hamilton, pointed out that it would take about a year to provide the rolling stock required, but his plea was in vain, and the original motion carried, Colonel Thomas Cantley, the retiring president, saying that the country should not get panicky; that in ten years all the Canadian railways will be able to stand upon their own feet.

Resolutions were passed supporting a tax survey, better fire protection, and research laboratories for Canada.

The Italian output of pig iron in 1916 is returned at 454,923 tons, as against 372,009 tons in 1915 and 424,099 tons in 1913. The imports last year were 302,333 tons, as against 240,366 tons in 1915 and 221,689 tons in 1913. The output of pig iron and the home consumption thus reached record figures. The output included 7,000 tons of electric furnace iron produced at Darfo, as against 2,800 tons in 1915. The output of charcoal iron was 5,090 tons.

THE USE OF CEMENT IN BULK.

As one measure of economy, why not ditch the cement sack when possible? Cotton, paper and burlap are scarce and high-priced. Unnecessary use of any of them is wasteful, and now is the time to eliminate all waste, says the National Portland Cement Association in a recent circular.

Sacked cement is largely a habit. We got out of the habit of using barrels because the cement sack seemed a more convenient package. But hundreds of thousands of barrels of cement have been shipped in bulk, and on jobs where its handling in this form is practicable, it has been found much more convenient than sacked cement and the expense of handling is considerably lessened.

There are, however, other advantages too important to be overlooked. If you buy a sack of cement its cost includes that of the sack. You can, however, get your money back for the sack if you take such care of it that the mill can again use it for a cement container. But your best efforts to do so go wrong at times because workmen find cement sacks very convenient for protecting their boots or shoes; have found that they make good tool bags; are often the handiest things to use to cover up work. In many other ways they misuse sacks or appropriate them without compensating the owner.

Objections have been advanced against using cement in bulk. Not one can be sustained if we credit the experiences of those who have used large quantities of bulk cement. It is no longer an experiment. It is, of course, not adapted to every job, but where cement is being used directly from the car at a rate of 50 barrels a day or more, bulk cement fits the job better than sacked cement. Various users report savings varying from 5 to 10 cents per barrel on bulk cement, as compared with sacked cement. Figuring 5 cents a barrel, this would mean a saving of $10 per car on the average carload.

Cement in bulk is not likely to suffer so much damage in transit as sacked cement. Even a leaky car results in less loss to bulk cement than to sacked cement. In the first case only a little cement is damaged; in the second case, more cement and a great many sacks are damaged.

Labor employed in emptying, shaking, counting, sorting, bundling and shipping sacks is done away with on bulk shipments. This has often resulted in increasing the efficiency of the construction gang about 10 per cent. in the amount of concrete mixed and placed.

Bulk cement does away with freight charges on returned sacks and the clerical work necessary to keep track of them until they have been redeemed.

No special equipment is needed to handle bulk cement from the car to the job. The same kind of wheelbarrow that is good enough to measure aggregates can also be used to measure cement. Less dust comes from handling cement in bulk than from handling it in sacks—there are no sacks to be shaken.

Bulk cement is particularly adapted to the requirements of concrete products plants. Tight, waterproof bins are, of course, necessary, but no other special facilities. Many products plants now use bulk cement only.

On large jobs money tied up in sacks represents money that might be better in working capital. Also, experience shows that the sack losses on most jobs of any consequence vary from 5 to 10 cents per barrel.

On many jobs it is not necessary to provide storage facilities for bulk cement. It is both practical and convenient to use it directly from the car to the job as needed. If storage is required, the ideal arrangement is the overhead bin, discharging by gravity as required.

Lake of the Woods To Be Regulated For Power

International Joint Commission Presents Report—Canada to Retain Control of the Norman Dam—Main Functions of Lake Recognized as Power Storage—Compensation for Land Damages

AFTER five years of investigation, the International Joint Commission has reported in favor of a high water level for the Lake of the Woods, recognizing that the dominant interests to be considered in that region are those relating to production of power and that the lake should be used as a storage reservoir to the greatest extent practicable. The Canadian authorities are to continue in control of the outlets, which are in Canadian territory, so long as the waters remain within the limits, 1,056 and 1,061 sea-level datum. But whenever the water rises above 1,061 or falls below 1,056 control shall pass to the International Joint Commission. So long as the waters of the lake are kept between the levels mentioned, only Canadian interests will be affected and, therefore, Canada will retain control. If the water rises above or falls below that range, international interests will be affected and international control will be exercised.

The conclusions and recommendations of the Commission are as follow:—

Summary of Conclusions and Recommendations.

Question 1.—The Commission answers that it is practicable and desirable to maintain the surface of the Lake of the Woods at a relatively uniform level throughout all ordinary seasons. In order to secure the most advantageous use of the waters of the lake, and of the waters flowing thereinto and therefrom, and of the shores and harbors of the lake, for the purposes stated in this question, the Commission recommends that the waters of the lake be maintained at an ordinary maximum stage of 1061.25, sea level datum, with a range from 1056 to 1062.50 representing respectively the extreme low level and the extreme high level. These extremes, however, in the opinion of the Commission, will be reached only in years of excessive drought and of excessive precipitation. The Commission also contemplates that in extreme low water years the water of the lake may be drawn below 1056, but only with its approval and upon such terms as it may impose. The Commission, as stated in its report, also considers that with proper storage and after experience has been gained in regulation, the ordinary maximum level of 1061.25 may be slightly increased.

Question 2.—The Commission answers that the ordinary maximum level of 1061.25, which it recommends, is 2.23 feet higher than the computed normal or natural level of the lake. Considering not only the low lands actually overflowed on the southern border of the Lake of the Woods or elsewhere on its border, but also the lands injuriously affected above the recommended ordinary maximum level through occasional flooding, wind effects and seepage, the Commission has concluded that flowage should be obtained up to contour 1064 sea-level datum. The Commission therefore finds that the areas, with values as at 31st December, 1915, for which flowage rights should be obtained, are as follows:—

United States, 23,968 acres, value $163,957, or say $164,000; Canada, 40,792 acres, value $80,877, or say $81,000; total value, $245,000.

The Commission estimates that the cost should not exceed $115,000 for the following:—

(1) The removal of buildings and compensation for loss of high land by erosion along the south shore of the lake in Minnesota;

(2) The necessary protection of the town of Warroad, including town lots submerged or injuriously affected;

(3) The necessary protection along water front in vicinity of Baudette, Minnesota and Rainy River, Ontario.

About $5,000 of this estimate is for protection on the Canadian side of the boundary at and near Rainy River; the balance, $110,000, is for lands and protective works in Minnesota.

Question 3.—The Commission answers that it is both possible and advisable to regulate the volume, use and outflow of the waters of the Lake of the Woods, as well as insure the adequate protection and development of all the interests involved on both sides of the boundary in the following manner:—

(1) By increasing the outflow capacity of the Lake of the Woods to 47,000 c.f.s. at a stage of 1,061 sea-level datum, costing about $175,000; and by compensating interests at the outlets and on Winnipeg River, involving about $25,000 and $30,000 respectively. The Norman dam in the Winnipeg River should be used for regulating purposes, and the cost of securing such use will have to be included. Should it be used for power as well as regulating purposes, then the necessary additional waste-way capacity will cost about $60,000.

(2) By taking advantage of the existing reservoir capacity of something over 100 billion cubic feet on Rainy Lake and the lakes immediately above Kettle Falls.

(3) By enlarging these reservoirs as soon as the demands for power warrant, so as to be able to store an additional 45 billion cubic feet—the cost of which is difficult to estimate at the present time.

(4) By international control of all dams and regulating works extending across the international boundary, also the dam at Kettle Falls in the Canadian channel, and, when the level rises above 1,061 or falls below 1,056, sea-level datum, the dams and regulating works at the outlets of the Lake of the Woods.

Problem Submitted in 1912.

The Lake of the Woods problem was submitted to the Commission on June 27th, 1912. The terms of the references, or questions, were as follows:—

(1) In order to secure the most advantageous use of the waters of the Lake of the Woods and of the waters flowing into and from the lake on each side of the boundary for domestic and sanitary purposes, for navigation and transportation purposes, for fishing purposes and for power and irrigation purposes, and also in order to secure the most advantageous use of the shores and harbors of the lake and of the waters flowing into and from the lake, it is practicable and desirable to maintain the surface of the lake during the different seasons of the year at a certain stated level, and if so at what level?

(2) If a certain stated level is recommended in answer to question No. 1, and if such level is higher than the normal or natural level of the lake, to what extent, if at all, would the lake, when maintained at such level, overflow the low lands upon its southern border, or elsewhere on its border, and what is the value of the lands which would be submerged?

(3) In what way or manner, including the construction and operation of dams or other works at the outlets and inlets of the lake, or in the waters which are directly or indirectly tributary to the lake or otherwise, is it possible and advisable to regulate the volume, use and outflow of the waters of the lake so as to maintain the level recommended in answer to question 1, and by what means or arrangement can the proper construction and operation of regulating work, or a system or method of regulation, be best secured and maintained in order to insure the adequate protection and development of all the interests involved on both sides of the boundary, with the least possible damage to all rights and interests, both public and private, which may be affected by maintaining the proposed level?

Over $100,000,000 Invested in District.

The drainage area tributary to the Lake of the Woods is 26,750 square miles, an area 5,000 square miles greater than that of the province of Nova Scotia, and exceeding that of all the New England States exclusive of Maine.

It would be difficult to overestimate the importance of the varied resources of the region, or the possibilities of their future development on both sides of the boundary. It is estimated that not less than $100,000,000 has already been invested in the district, including the lumber industry, pulp and paper mills, power plants, flour mills, fisheries, etc. The paper mills at International Falls and Fort Frances are among the largest in America, and the flour mills at Kenora have a daily output of nearly 10,000 barrels.

Over 500,000 horse-power is available on rivers flowing into and out of the Lake of the Woods. Two out of ten available power sites on the Winnipeg River alone, producing at the present time 53,000 horse-power, represent an investment of $18,000,000. This power is transmitted to the city of Winnipeg. The total capital investment directly dependent upon this Winnipeg River power is given as $170,000,000, with an annual payroll of $24,000,000 and an annual produce worth over $135,000,000. This is the result of developing only 53,000 horse-power out of a total of 420,000 on the Winnipeg River.

Through its consulting engineers, Adolph F. Meyer, of Minneapolis, and Arthur V. White, of Toronto, with the aid of well-equipped field parties, the commission carried out comprehensive surveys of the Lake of the Woods, Rainy Lake and the principal lakes tributary to the latter. It also secured a great deal of hydrological and meteorologic data. Most of this information had to be obtained at first hand, as very little was available in the government records, on either side of the boundary. The Lake of the Woods region is somewhat off the beaten track, and the Commission had in many respects to blaze a new trail.

The results of many of these surveys and observations have been previously published in numerous articles in *The Canadian Engineer*.

The International Joint Commission consists of six members. The three appointed by the United States are: Hon. Obadiah Gardner, of Rockland, Maine; Hon. James A. Tawney, of Winona, Minnesota; and Hon. Robert B. Glenn, of Winston-Salem, North Carolina. The three appointed by the Canadian Government are: Charles A. Magrath, of Ottawa; Henry A. Powell, K.C., of St. John, N.B.; and Paul B. Migault, K.C., of Montreal. Senator Gardner and Mr. Magrath are the joint chairmen of the Commission.

It has been calculated that the rivers of European Russia alone, excluding the Caucasus, are capable of producing 1,000,000 horse-power. Together with Siberia and the Caucasus, Russia possesses reserves of this energy which exceed 10 million horse-power.

NEW DESIGN OF SCREEN CHAMBER.*

By John H. Lance,
Consulting Engineer, Wilkes-Barre, Pa.

IN the use of water for supply purposes its freedom from foreign bodies is of prime importance. While ordinarily, the water of driven or dug wells or infiltration galleries is free from detritus, all stream, reservoir and lake supplies require careful screening before the water may be admitted to the distribution system. Among the bodies to be removed from the water are grass, leaves, sticks, bits of bark, and fish; and by far the most troublesome of these are leaves in all stream and

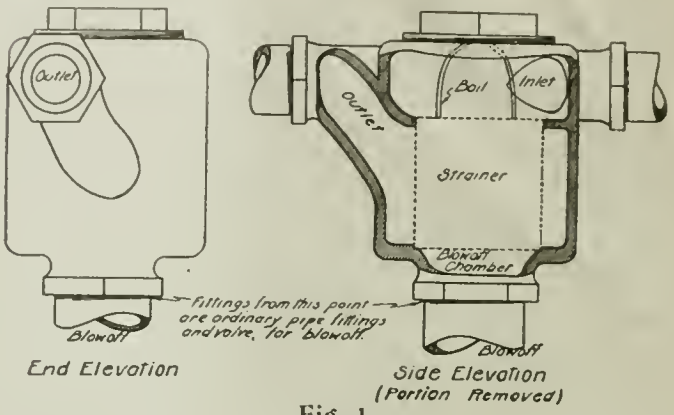


Fig. 1.

small reservoir supplies. Masses of water grass only occasionally move to the point of intake; sticks, etc., usually only by reason of a high stage of water in the source of supply. Unlike these substances—which do not often of themselves form, by lodging against the screen, a tight barrier to the passage of water—leaves may practically seal the screen and effectually shut off the supply. This result may be caused also, but rarely, by small fish, of such a size as to be unable to resist being carried by the current at the intake. When they have been held against a screen for 24 hours these fish make a tight seal and a very difficult coating to remove, one that does not readily release when the pressure is removed, as do leaves. Only the rarity of conditions favoring such occurrences spares the waterworks operatives a vast amount of trouble. On the other hand, the leaf nuisance, especially in supplies from small reservoirs and streams, makes constant demands upon the attention of the operatives for a considerable part of the year.

The customary method of removing these substances is to install at the intake of the supply main a screen affixed to the pipe, or two sets of screens in series, which may be drawn up out of the water for cleaning and replaced again for service. The former arrangement, which is applicable only to very small depths of water on the screen, is economy itself in first cost, but its use has not always proved so economical, as, owing to any one of many causes, the screen might not receive the necessary attention at the very time when it was most needed. The latter necessitates a considerable structure to hold the screens in place and house them while being cleaned. If the reservoir is of great depth the process of cleaning is tedious and expensive, involving, as it does, the hauling up of all the screens in one set and their replacement for each cleaning. During the time of cleaning the upstream

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*Paper read before the American Waterworks Association, May 9th, 1917.

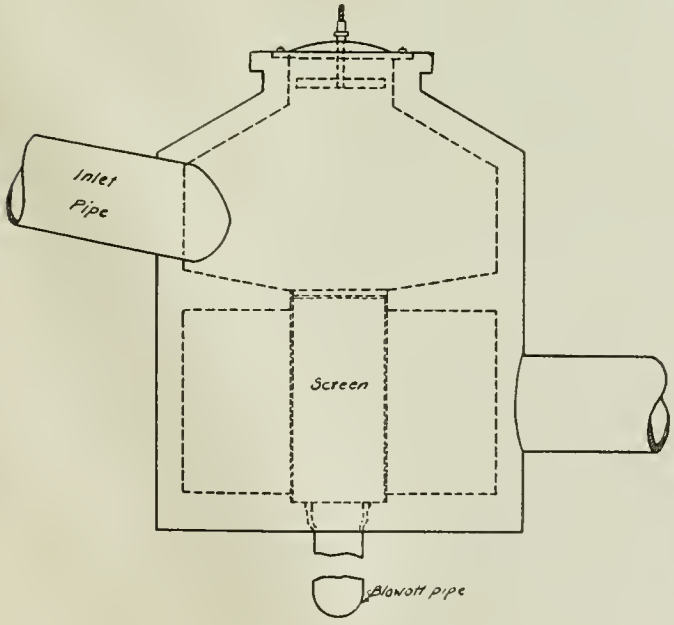
set the downstream set is receiving leaves and trash. While the cleaning of this set takes place much of the debris lying against the screen and any fish between the two sets go down into the supply main to appear at the various fixtures of consumers or block the operation of meters.

To obviate these difficulties the pressure screen-chamber here described was designed. It consists essentially, as shown in Fig. 3, of a vertical cylinder divided by a horizontal diaphragm into two compartments. The upper, or inlet compartment, has communication with the lower, or outlet, through a circular opening in the diaphragm, and thence through the meshes of an open-ended cylindrical screen resting in the lower compartment of a diameter nearly that of the opening. The lower end of the screen is concentric, with the end of a blow-off pipe with a gate valve on it, normally closed. The inlet pipe enters the inlet compartment tangentially, while the outlet may leave in any direction relative to that of the inlet, preferably in a radial position. Any flow from the inlet pipe sets up a whirling motion in the water in the upper compartment. In passing through the screen cylinder it has a circumferential as well as a downward motion, which, owing to the passage of water through the meshes of the screen, diminishes as the bottom of the screen is approached. The result of this is to confine, largely, the foreign matter carried by the water to a central cone, the base and height of which are approximately those of the screen. The upturned end of the blow-off pipe being made of nearly as great a diameter as the screen, this results in an accumulation of debris directly in the pipe. When blocking of the screen has progressed to a point at which there is a noticeable loss of head at the screen, as measured—preferably by a mercury U-tube or a differential gauge—the blow-off gate is opened. The head in the blow-off pipe is then reduced to zero, or nearly so, the hydraulic gradient from reservoir to screen-chamber is increased, and the high velocity established is transmitted directly to the water passing diagonally downward over the face of the screen and out the blow-off pipe. Ordinarily, the cleaning of the screen is accomplished in about the time that it takes to open and close the

Fig. 2.

blow-off gate. If it is desired to maintain a considerable continuous flow through the outlet pipe the blow-off gate need not be opened wide, in which case the operation will require a longer time. Under no conditions is an appreciable amount of water wasted.

Also incorporated in the design is a hollow segmental brush for use in cases when the screen does not get attention for such long periods that a deposit of small fish is not readily removed by the flowing water. For the intake pipes of pumping stations the devices are best set in batteries of two, so arranged that one can be put



Typical Cross-section of Trench.

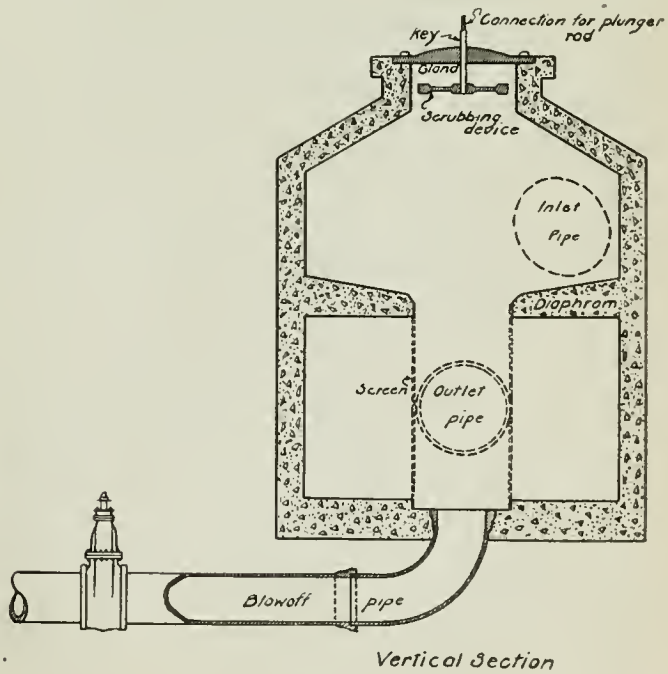


Fig. 3.

in service while the other is being cleaned. In this case the cleaning is preferably done by jets of high-pressure water directed downward from the edge of the diaphragm across the screen. Where electric power is available the use of proper contact devices at the point of measurement of the loss of head at the screen will make the entire screening operation automatic, both for gravity and pumping supplies.

For use with a gravity water supply, the devices have been found to operate most successfully between the heads of 40 and 60 feet, though there is no valid objection to their use at other heads under certain conditions. They are made entirely of reinforced concrete, with the exception of the manhole cover, which is of cast-iron. Fig. 2 shows one of two screen-chambers under construction on two 30-in. mains under a head of 60 ft.

The principle of pressure screening, from which the design was developed, was first suggested by Mr. O. M. Lance, general manager of the Spring Brook Water Supply Company. The operation of the screen-chambers has been found to be so economical and efficient that they have been adopted as a standard by the above-named company as convenient. Its supply lines, twenty in all, will be equipped with the new device and the old sliding screens removed, only bar screens being left in place.

The application of this development is quite wide and covers a variety of uses, such as meter fish-traps, sewage sludge screens, etc. It is covered by letters patent. Fig. 1 shows a small cast metal screen chamber for use with a meter.

SHIPBUILDING IN JAPAN.

Large extension of equipment is projected by the Mitsubishi Dockyard and Engine Works at Kobé. This company is to build four steamers this year, ranging from 2,000 tons to 6,000 tons, while the construction of other vessels is also contemplated. To meet the increased demand for building capacity, the management has undertaken the construction of two new docks, and a new floating dock of 20,000 tons lifting capacity. It is said that when these projects are completed the Mitsubishi yard in Kobé will be able to build ships aggregating 60,000 tons a year. The new floating dock will be moored in the new basin as soon as the breakwater of about 1,000 ft. is completed. This breakwater will run from the end of Wada Point, nearly parallel with the existing inner breakwater of about the same length. A new engine shop is now being constructed with the intention of manufacturing Diesel engines for land and marine purposes, especially for submarine boats, together with petrol engines for aeroplanes, motor boats and motor cars. The new shop is expected to be finished by about the middle of this year. It has also been decided to commence the manufacture of the "Stal" type of steam turbine.

A poll of the ratepayers of Cape Town has resulted in sanction being given to the raising of a sum of £268,000 for defraying the cost of the following: (a) The provision of a new reservoir of 200,000,000 gallons capacity in the Silvermyn Valley, in the Muizenberg Mountains, by the construction of a concrete dam, at an estimated cost of £205,000; (b) the provision of a line of 12 in. cast-iron pipes between Muizenberg and Newlands, at an estimated cost of £35,000; (c) certain investigations in regard to water supply, at an estimated cost of £15,000; and (d) the provision of buildings, fittings, cleaning, drying and curing areas, water drainage, sanitary conveniences, etc., required at the new fishing harbor, at an estimated cost of £13,000.

OUR WAR PROBLEMS.*

By J. S. Dennis,
President, Canadian Society of Civil Engineers.

I UNDERSTAND the main object of your gathering here is to consider the question of a possible federation of the engineering associations or societies in the United States so as to bring about better results. It occurs to me that federation has never been accomplished in an entirely peaceful manner, which leads me to the thought that perhaps that is the reason why your chairman has included me on the program to speak on the subject of war problems.

Your own federation in the United States, when it saw fit to cut loose from the British Empire, was not accomplished in a peaceful manner. The subsequent effort to maintain your federation through the Civil War was not peaceful. The federation of our British colonies also led to bloodshed, and therefore it is natural for us to expect that largely scattered and diversified interests like those of the multitudinous engineering organizations on your side of the line or ours, cannot be federated or consolidated without trouble, but there is no doubt whatever in my mind that if, as a result of your conferences here, anything in the way of federation of the different societies can be accomplished, you will have made a great step forward.

We in Canada have the same problem confronting us. We have all the branches of the engineering profession represented there in different societies or clubs, and our desire is to try and federate and consolidate them into one central organization, at least, in so far as a central board is concerned.

Our main object in the Canadian Society of Civil Engineers is to encourage, as far as Canada is concerned, exactly what I understand you are aiming at,—that is, a federalization of all of the engineering societies in Canada, and we have under consideration the change of our name so as to extend an invitation for all to come in and create a big federal organization. My particular object this year, as president of the Canadian Society of Civil Engineers, is to endeavor to get the society to go outside of the ordinary routine of strictly professional or technical subjects and take part in the bigger and broader problems that are confronting us in Canada as a result of the war, and in this I may say we have accomplished something.

We have in Canada certain problems which have come to us as a result of our participation in the war. Probably among the most important of these is the question of how we can increase the production of our country by the development of our natural resources. We think Canada has been blessed by Nature with almost inexhaustible resources of water-power, timber, minerals, agricultural lands, and so on, and therefore as a society we are urging that special study be given to the question of how Canada's natural resources can best be developed. Our Dominion authorities have created a commission to study this problem, and the chairman of one of their important sub-committees is the chairman of our finance committee.

We have in Canada another big problem connected with our transportation systems. Canada to-day has a greater mileage of railway in operation per capita than

(Concluded on page 527.)

*Abstract of address before the Third Conference, Committee on Engineering Co-operation, Chicago, March 29, 1917.

CANADA'S RAILROAD PROBLEM

The Objections to Government Ownership—Party System Militates Against It—State Ownership and Inefficiency.

By W. T. JACKMAN, M.A.,
Dept. Political Science, University of Toronto.

NOTE.—The following article is the second of a series of three. The objections to Government ownership of Canadian railroads are discussed. In his first article, published in our May 3rd, 1917, issue, Mr. Jackman considered the advantages of Government ownership. In the third article, he will propose remedies for our existing difficulties. Mr. Jackman is not an engineer, and his opinions are expressed from the economic viewpoint only, but they will no doubt interest readers who have followed the papers by Messrs. Tye and Tait and the report of the Railway Inquiry Commission.—Editor.

HAVING looked at the advantages of government ownership, it will be well to consider, in the next place, the objections to or disadvantages of government ownership. In the administration of a railway system or any other large enterprise, prompt action is an imperative necessity in order to be able to meet the emergencies that are constantly arising. There is need for instant action in the despatch of business and in order to secure judicious outlay in the interest of economy. The many changes in commercial conditions, of which business men endeavor to take advantage, should be met by the agents of the railway companies armed with authority to grant traffic arrangements to meet the necessities of their patrons. A delay of even a few days may be fatal. So, too, in regard to line expenses; the replacing of a bridge in time, the ballasting of the roadbed when required, the changing of gradients and curves, and many similar items, when effected at the proper time will save large amounts in the expenses of operation and in many instances will provide the public with greater facilities and greater security. When private control is exercised the management is left in the hands of a capable executive, from whom immediate action may be obtained under all circumstances. In this way, not only the welfare of the company may be secured but also the interests of the public may be advanced. But Parliament is too unwieldy a body through which to secure immediate action. Any measure which is brought before the legislature becomes at once the subject of discursiveness in debate. It is referred to a committee for recommendation and the minute regulations under which Parliament proceeds, being determined by law, leave no power of initiative to the railway executive. Since the master has no power of initiative it cannot delegate any to the servant.

Parliament is Too Slow.

Parliament is altogether too slow in its deliberations to be the directorate of a great railway system. Its members, representing widely separated localities with much diversity of interests, are sent to Parliament to act for the well-being of their own sectional or partisan interests and are in nowise able to see things from the larger point of view when it comes to the time for casting the vote. Out of this confusion of interests we cannot expect and do not find decisive action for the public welfare. Decisions which are finally reached are mostly compromises in order to adjust most amicably the vast variety of interests; and such indecision and compromise are fatal to the success of any large business of an economic character.

No official can administer the affairs of such a complex and changing mechanism as a railway system with even reasonable efficiency unless funds are at his disposal when they are needed. If otherwise, waste goes on, with misfortune to the property, to the owners, to the bondholders and to the public. When authorizations of funds are delayed for months, and sometimes for years, the effect is invariably and unavoidably increased cost of construction, maintenance and repair work, together with increased interest charges the longer the appropriation is delayed, and greater loss through the deterioration of the plant. It cannot be otherwise. Taking this in connection with the administrative expenses, which go on whether the property can be operated efficiently or not, we have a clear view of one great reason why governmental activity should not be exercised in regard to the administration of railways.

Party System and Railroads.

Another factor which militates against government ownership of the Canadian railways is our party system of government, with all that this includes. At a change of the party in power there is always so much undoing of work that had been done by the previous party in control. An uncertain, unstable policy of government is not conducive to the building up, upon a permanent basis, of a railway system that will be of national importance. In building for the future those who are entrusted with these responsibilities need to be assured that a continuously consistent policy will be shown, so that enterprises which have been initiated may be assured of completion. But this is impossible under our government with its vacillating policy, for public works which have been supported by one party when in power will be relegated to obscurity by the other party when it secures control. The result is that such works lack adequate continuous financial support until their completion, and so we have piecemeal construction, patchwork planning and temporizing operation. Public enterprises, like those of a private nature, must have the continuance of conditions upon which they can depend in order to build for the future; the lack of this essential would surely prove detrimental in devising the means for meeting future needs and emergencies. The influences of party and sectional demands have been all too apparent in recent years since the rise of the great agricultural western provinces, and while we do not, in the least degree, condemn those who have such influence for exercising it for the improvement of their economic condition, it furnishes us a striking example of the way in which partisan claims secure recognition at Ottawa.

Works for Inefficiency.

In a democratic state, not only has the direction of state-owned railways an overwhelming tendency toward inefficiency, but even the management partakes of the same character. We will recognize, however, that there are exceptions to this rule. Managers are not chosen because by training and experience they have fitted themselves to direct the affairs of a great enterprise, for government officials are usually selected on another basis than ability and aptitude in the special line of duty to which they are assigned. It does not follow that, because a man has ability in business life or skill as a physician or lawyer, he can be placed at the head of large railway interests after he has had experience in Parliament.

The work of a capable railway executive is as much a specialized calling as is that of a doctor or lawyer, and for its successful accomplishment requires training and intellectual ability of a high order combined with broad

practical experience in the important grades of the service. To place any other kind of man at the head of a great railway would be to place a premium on incompetency, to create a misfit in one of the most important offices of the public service and to give rise to demoralization of the entire body of servants in the integration of their activities. In order to acquire a knowledge of any of the higher positions in the railway service a long period of educative and disciplinary experience is required; and in the case of the highest official, upon whom devolves the responsibility and control of the entire system, it would be a gross delusion to think that one without any railway experience, or even one with experience in only one aspect of the service, no matter how great might be his ability along other lines, could adequately measure up to the demands attendant upon this office. Moreover, under our form of popular government administrative officers are frequently changed and with changes in the heads of departments there are many changes also in the important clerkships under them; and until these new men learn the details of their business their work bears the impress, to say the least, of immaturity and incompetence. Such conduct in connection with the railways of the country would be disastrous from every point of view. Expediency, under these circumstances of political change, would lead the officials of a railway to make a good showing in connection with the business over which they were given the temporary control; but in order to make a good showing in governmental enterprises we have seen the permanent upkeep and expansion curtailed in order that the affairs might show a favorable balance of profit. This tendency of managements, whether municipal, provincial or national, leads to a continuously short-sighted policy of retrenchment in necessary expenditures; and when due correction is made of the "favorable balance," upon grounds of prudential disbursement, the result would, in many instances, be a deficit.

Initiative is Checked.

Again, the relation of the executive to the directorate in governmental enterprise is not such as to lead to efficiency. The constant ebb and flow in industry and commence which are so marked a feature of all our economic life necessitate frequently immediate action on the part of railway officials. We have seen this exemplified in many ways in the past few months, by the exigencies attending the moving of the crops last autumn and the provision of a supply of coal and agricultural necessities during the present winter. Under these conditions, the railway manager requires to have large authority and discretion vested in him, so that he can meet the unforeseen situations most effectively. But, were he the servant of government, he would not be allowed to act upon his own initiative, for under our government executives are restricted in their power so that the rights and liberties of the people may not be abused but fully conserved. To circumscribe an executive in this way, and cause him to act under a diffused authority which is so remote from him that he cannot secure immediate consultation, is to paralyze all his efforts, be they never so wisely conceived, and to induce indifference and inertia. Of course, the same characteristics tend to be produced in the men who are working under such an executive. This is one of the most incisive arguments against government ownership. How can a railway manager secure results unless he has full discretion as to methods to be pursued and the personnel and promotions of the men who are to be his most intimate and trusted associates?

Finally, the management, under government ownership, has lost all the incentive of self-interest, which is such a potent factor in securing the great results that have flowed from private ownership. Giving due consideration to the evils which have followed private ownership, will anyone say that the unprogressiveness and lack of interest of government employees, the great army of whom know that promotion is for them a question of remote possibility, does not bring as great, if not greater, evils for the community? In the case of a great corporation, each employee wants to do his best in order to secure the promotion and other recognition that he desires. Only in this way can he secure this result, for it is very rare that, in a private concern, an incompetent will be advanced over the head of a competent individual. But promotion is not obtained in this way in government service, for here all the elements of personal influence and political favoritism which are commonly included under the term "pull" are invoked in order to bring preferment to a particular candidate.

To be sure, where civil service rules are applied the above methods are modified in a degree. But lack of immediate and personal self-interest on the part of government employees tends to retard or prevent the latter from displaying the inventiveness and resourcefulness which characterize the servants of a private corporation and which are such an important feature in the development of industry and enterprise. The inability of the individual to secure recognition tends to degrade the standards of personal efficiency in government service; and this would have very unfortunate ulterior results were the railways to be taken over by the government.

Financial and Political Objections.

In addition to the foregoing objections from the standpoints of control and active management, there are also financial and political reasons why government ownership is undesirable. Granting that the government could borrow, at the rate of, say, 3½ per cent., all the money required to refund the outstanding bonds of the companies, those persons and institutions which now hold these bonds would have to accept in lieu of them the government bonds bearing the lower rate of interest. This reduction in the earnings of the securities would bring financial difficulties to banks, insurance companies and private individuals as owners of these securities. But it is greatly to be doubted if the government could borrow all the money it required for such a large financial venture as the purchase of the country's railways and of adequate facilities in the way of rolling stock and terminals to handle the increasing volume of traffic.

It is able, under ordinary times, to borrow at such low rates simply because it has not abused its credit. But the facts which have been brought before us on account of the war have put an altogether new look upon the problem of finance. Even those great countries like England and France with almost unlimited credit have had to pay much higher interest rates for their increasing necessities; and Canada, in order to secure her latest borrowings, has had to offer a rate of interest enormously greater than we have assumed above for purposes of argument. If these high rates had to be paid by the Dominion for the capital required to finance the purchase and equipment of her railways, the financial argument for government ownership would be utterly ludicrous. As an addendum to this, we must note that if the Dominion government took over the railways, the provinces would lose in taxation a considerable amount of money—in 1915 the tax bill was $3,049,727.62.

The political argument against government ownership of the means of transportation is also strong. In

Parliament, representatives from the various and widely scattered sections of the Dominion meet to consider measures for the country's welfare; but each of these men, by the mere fact that he is the representative of his own community or class, is, by implication, bound to do all he can for his own constituency. Now, the government acts according to the amount of pressure that can be brought to bear in connection with a particular issue; that is, according to the number of votes which that issue can command. Hence, the greater the number of votes which can be secured in favor of a bill the greater is the probability that such a measure will be enacted into law. It is evident, therefore, that one of the advantages of government ownership which we have explained rests upon a very slippery foundation; it is not by any means the needs of the various sections of the country that is the basis for their consideration by Parliament, but rather the influence that can be exerted by all the forces to which the legislature has to listen.

Let not the advocates of government ownership think that with all these transportation facilities in the hands of the government a "square deal" will be received by every locality; for he who realizes how the government does its business will be fully conversant that this much-desired equity would not be initiated or applied under the proposed control. Those sections which can bring forward the greatest pressure will get the "plums"; and other sections will be left without the means of conveyance and communication until they can exercise sufficient influence politically to compel recognition of their needs.

Increase in Employees.

Another phase of this political argument is that whenever governments have taken over railways from private control there has invariably been an increase in the number of employees who are given positions in the service. The necessity of giving these appointments so as to secure the largest number of votes is recognized by all parties. This would have a two-fold influence: in the first place, the large increase in the number of employees would soon be in a position to cause even their superiors to tremble before them; and in the second place, the large increase of expenditures in salaries and wages would soon be followed by the necessity of higher rates out of the proceeds of which to pay the larger pay-roll. In the event of failure to provide the higher rates, the management would have to call upon the government for greater appropriations of public funds to make up the deficits from revenue. But the political side of this issue can be easily seen when we note that with a greatly augmented force of government officials and employees the latter might be able to hold the balance of power between two parties and thus compel the payment of higher wages or the grant of shorter hours or other privileges.

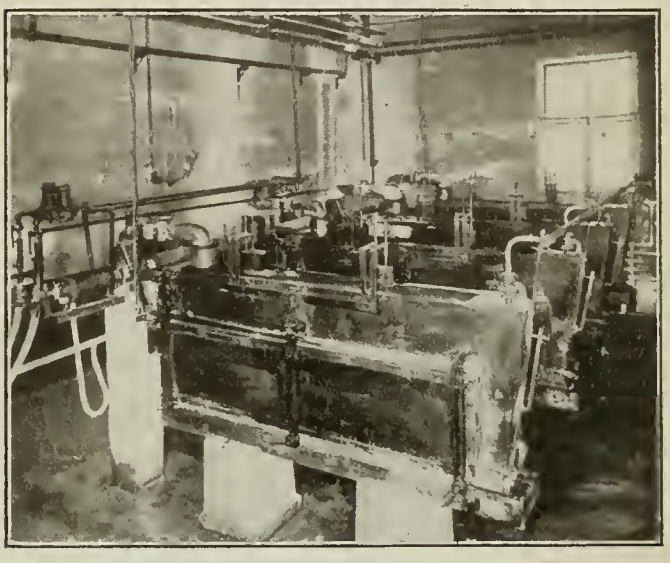
ELECTRICAL BOARD NAMED.

George L. Guy, electrical engineer for the Manitoba public utilities commission, J. M. Leamy, provincial electrical engineer of Manitoba, and G. J. Brown, assistant to Mr. Leamy, have been appointed a board of examiners under the act for the licensing of electricians. The board will have to arrange for an examination of candidates before the end of the year, as after January 1, 1918, penalties will be imposed on all electricians working without a license.

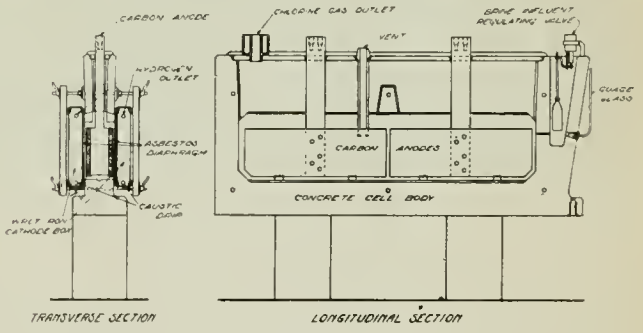
The electric furnaces of Sheffield, England, can now produce 90,000 tons of steel per year, and in 1918 it is anticipated that the output from these furnaces will be 150,000 tons.

MONTREAL WATER AND POWER COMPANY'S CHLORINE CELL INSTALLATION.

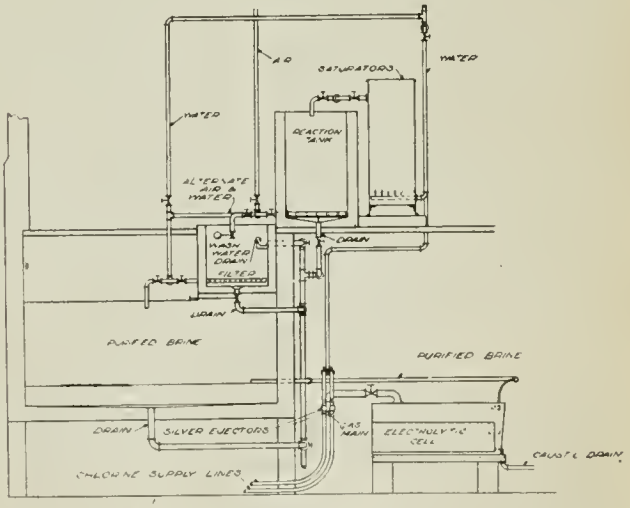
Under the above heading an article appeared in the May 31st issue of *The Canadian Engineer*, by F. H. Pitcher and J. O. Meadows. Through the courtesy of Mr. Sutherland, assistant chief engineer of the company, we have since been placed in possession of the following two drawings and one photograph, which will be of interest to engineers who have read the aforementioned article.



View Showing the Four Electrolytic Cells in Use.



Detail of Cell, Electrolytic Chlorine Plant.



Sectional Elevation Showing Brine Purifying Apparatus and Electrolytic Cell.

DUTY TRIALS ON PUMPING ENGINES AT JOHN STREET STATION, TORONTO.*

By Robert W. Angus, B.A.Sc.,
Prof. of Mechanical Engineering, University of Toronto.

ALL of the water used by the city of Toronto is pumped through the main pumping station at the foot of John Street. This station is equipped with a number of steam-driven pumps and also a number of electrically driven units, the latter receiving electric current from the general city supply. In so far as the electrically driven units can be operated without raising the city's power peak, they are kept in service, but whenever the electrical operator finds that the peak is being approached, he has one or more electrical pumps stopped and then the delivery pressure of the station may slightly decrease while a steam pump is being brought into service, but, on the whole, these variations in pressure and in supply are not noticeable in the city.

Description of the Units.

Some few years ago it was decided to increase the pumping capacity of the main station, and, with this in view, a new pump room with adjacent boiler room was built. The pump room now contains five pumping units, two of which are driven by induction motors, and three of which have been built by the De Laval Company, and are driven by steam turbines. It is with two of the latter pumps that this report deals.

Each unit consists of a De Laval steam turbine connected through a reduction gear to a pair of centrifugal pumps, which are connected so as to work in series. The units are exact duplicates. The turbines are of standard De Laval construction for steam pressure of 150 pounds and a vacuum of 29 inches, the normal speed being 3,430 revolutions per minute. Each is direct-coupled to a speed reduction gear having a ratio of 33 to 197, so that the pump shaft rotates at normal speed of 575 revolutions per minute.

The steam supply pipe is 4½ inches, with 36-inch exhaust to a standard Wheeler surface condenser, so placed that all the water delivered by the unit passes through it as cooling water before reaching the main pumps.

The vacuum pump is a 20-inch x 40-inch Rotrex pump built by the C. H. Wheeler Company, and is direct connected to a 7-inch x 7-inch engine designed for a normal speed of 200 revolutions per minute, but which ran at a much lower speed during the trials. The exhaust from this engine is delivered back into the steam turbine somewhere near the middle stage, and is made use of in doing work there.

The boiler feed pump is chain-driven from the pump shaft. It is a Goulds single acting triplex plunger pump with plungers 3½-inch diameter and 6-inch stroke, and in one of the units the crank shaft driving the plungers turns at about 47 revolutions per minute, a speed which is too low to supply the necessary feed to the boiler for this pumping unit; in the other unit the speed is 66 revolutions per minute, which is satisfactory.

There are two single-stage double-suction pumps on each unit, the two pumps being piped together in series. There are no outside guide vanes, but the castings are of the volute form and the pumps run very quietly. The name-plate states that the pump is designed for a total head of 250 feet, and a discharge of 20,000 U.S. gallons per minute (which is equivalent to 24,000,000 Imp. gallons per 24 hours) at a speed of 575 revolutions per minute.

The water piping begins with a 42-inch suction, which is the size of the inlet to the condenser. At the condenser outlet the diameter is reduced to 36 inches and this is again reduced to 24 inches where it enters the pump. The series piping between the pumps is 30 inches, being reduced to 24 inches at the point of connection with each pump. To the discharge end of the pump a 24-inch x 36-inch tapering enlarger has been attached to connect with the 36-inch discharge main. The inlet and outlet openings on all the pumps are 24-inch diameter. The pump impellers are of bronze.

The Duty Trials.

The duty trials on the machines were run on March 6th and 8th, 1917, respectively, and in order to see that the conditions were uniform before the tests began, the machines were run for at least an hour under full load immediately preceding the duty trial.

The boiler fires were properly cleaned, and everything put in as good condition as possible to insure uniformity, but some slight variations naturally occurred. It was necessary to run the trials during the daytime, owing to the demand for water in the city, and therefore an effort was made to start as near seven o'clock in the morning as possible, although in both cases the trials did not begin till nearly an hour later.

The city's electrical power peak occurred shortly after the trial began in each case, and the electrical pumps were therefore shut down, causing a heavy draught on the pump under test. There was a consequent decrease in pressure, but as the discharge increased at the same time, the load on the steam turbine driving the pump did not vary greatly. Throttling of the pump discharge was temporarily resorted to, in order to prevent undue fluctuations, and another steam pumping unit elsewhere in the station was put into service as quickly as possible, but the extra draught of steam from the boilers caused some slight variations in steam pressure. All of these variations, however, were of short duration and were productive of but slight inconstancy in the general conditions, and the machines were given exceptionally steady loads during their entire trials.

Conditions Governing the Trials.

In the contract dated August 14th, 1914, the conditions governing the conduct of the duty trials are given, and the following clause referring thereto is copied here for reference:—

"59. While the duty specified for the steam turbine driven unit is 120 million foot-pounds, tenders are requested to state any higher duty they are prepared to guarantee, and any higher duty guaranteed, together with the contractor's ability to fulfil same, in the opinion of the commissioner, will form a factor in the awarding of the contract. Should the contractors guarantee a duty in excess of that specified, when using saturated steam containing not more than 1½ per cent. of entrained moisture, the duty guaranteed will be substituted for this amount, and for each one million (1,000,000) foot-pounds in excess of the guarantee the corporation shall pay to the contractor the sum of fifteen hundred dollars ($1,500), and pro rata for fractional parts, but the total bonus shall not exceed seven thousand five hundred dollars ($7,500). Should the duty as shown by the official trials be less than the guarantee the commissioner shall deduct from the

*From report made to R. C. Harris, Commissioner of Works, Toronto.

amount paid to the contractor the sum of two thousand five hundred dollars ($2,500) for each one million (1,000,000) foot-pounds unperformed, and pro rata for fractional parts down to five million foot-pounds less than the guaranteed duty.

"If the duty as shown by the official test be more than five million foot-pounds below the guaranteed duty, the commissioner may, at his option, reject the unit, and in case of such rejection, the contractor shall return all moneys paid to him on account and shall, without compensation, allow the unit to remain in the service and under control of the commissioner for such a time as may be required to install a new unit, and shall fully reimburse the city for any loss or damage suffered by reason of the contractor having failed to fulfil his guarantee."

In accordance with clause 59, the contractors guaranteed a duty of 141.5 million foot-pounds of work per 1,000 pounds of steam used, and this duty was therefore inserted in the contract.

Details of the Trials.

The duty trials were run in exact conformity with the specifications, with the single exception of the duration of each, which is specified as twenty-four hours. On discussing the matter with the city's engineers, it was found that the conditions in the station made such a long run very undesirable, and it was agreed that the run should be shortened to ten hours. The contractor agreed to this. There is no doubt that the results for the ten-hour period would be practically identical with those for twenty-four hours.

The specifications require that the gauge pressure on the boilers supplying the turbines shall be 150 pounds per square inch. A battery of four boilers was used in each case, and on top of each boiler there is a stop valve bolted to the steam drum, and from the top of this stop valve the steam pipe from the boiler leads to a header which is common to all boilers. To this header the supply pipe for each pumping engine is connected by a fairly long, well-lagged pipe.

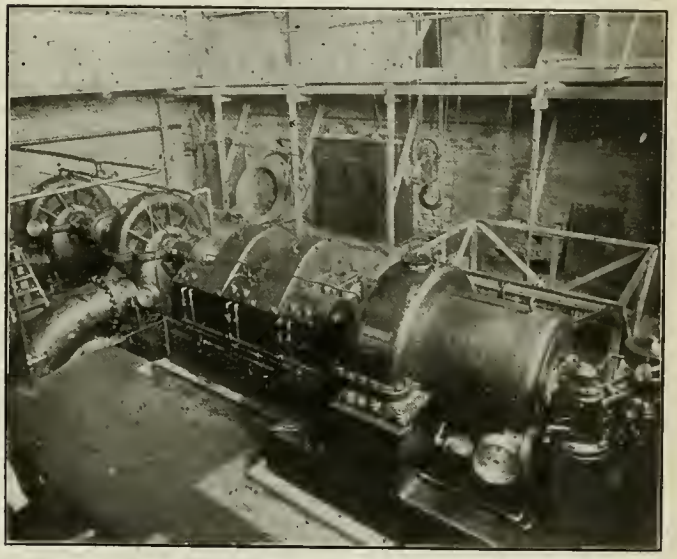
To avoid any possible sources of loss in the boiler stop valve, the gauge used on the trial was connected to the steam pipe within six inches of the stop valve. The gauge pipe was so arranged that the gauge was brought down to the level of the fireman's eye, and correction was made for water column. An observer remained constantly in the boiler room so as to keep this pressure uniform, and readings were noted every 15 minutes.

The quality of the steam was taken by throttling calorimeter attached to the steam pipe about six inches from where it entered the turbine stop valve. For the purpose of determining the quality, the engine pressure was taken and is also recorded; it was taken at the point where the calorimeter was attached. These readings were at 15-minute intervals.

To determine the exhaust steam condition, both a mercury column and a thermometer were used, the mercury column being attached to the turbine casing slightly below the level of the main shaft, while the thermometer was inserted in a cup in the exhaust pipe about half-way between the turbine casing and condenser. Much care was taken to push the thermometer well into the cup, so that the bulb was at least 9 inches in from the pipe wall, and the mercury column connections were also carefully tested for leakage. A comparison of the two readings shows that the temperature is lower than that corresponding to the mercury column, possibly due to the difference in location, and partly to the presence of air in the exhaust. Both results are quite accurate and equally reliable.

The speeds were taken with an ordinary revolution counter, or else were actually counted, those on the main pump being at 15-minute intervals; the others were not so frequent. It was not possible to get the speed of the steam turbine directly, and hence it had to be calculated from the pump speed, using the gear ratio given by the contractor of 197 teeth in the gear to 33 teeth in the pinion. The pump and turbine speeds were well below the maximum specified.

To get the steam used during the trial, the ordinary pipe for delivering the condensate into the feed tank was broken and a connection put in so that the water was delivered into a storage tank, from which it was run into a tank on scales as desired. The leakage from the air pump glands was caught and has been added to that coming directly from the air pump discharge. There was only one trap on the turbine plant, and as it was plugged no leakage occurred there.



Steam Turbine Driven Pumping Engine at John Street Pumping Station, Toronto.

On the first unit tested the gland leakage was not great, but as it was in the form of steam it could not be measured. In the second unit the leakage was much more marked, due to defective carbon rings, but the steam thus escaping would not have formed any appreciable proportion of the total, and its effect on the duty would be very slight.

The weighing tank was capable of holding a net weight of only about 1,000 pounds, and, in order to keep well within the limits, the weight of steam condensed every three minutes was taken. In order to have no error due to the storage tank, the water in it was brought to the same level at the end of the test as at the beginning. All weights were taken to half pounds. The steam used by the air pump is automatically included with that from the turbine, and the feed pump was chain-driven from the pump shaft.

For convenience and greater accuracy the pressure and suction gauges were both piped to the same point, close to the suction inlet pipe, and in the results allowance was made for the difference in levels between them.

Before the test began, considerable discussion took place between the contractors and myself regarding the position of the discharge gauge connection, and also as

to whether velocity head was to be allowed for. In this connection it is pointed out that the suction pipe up to the condenser is 42-inch, and the discharge outlet from the pump 24-inch, and a tapering enlarger and valves are used to connect the 24-inch pump outlet to the 30-inch delivery pipe provided by the city. The difference in pressure between the two ends of this enlarger was slightly over 7 10 pound per square inch, being greater at the 30-inch end, and amounted to about 7 10 of one per cent. of the total head. The nature of the specifications prevented allowance being made for difference in velocity head between suction and discharge pipes, and it was also agreed that the discharge connection should be placed on the outlet from the pump where its diameter was 24-inch, and the results are reported on this basis.

The discharge pressures were taken with a sensitive Bourdon gauge, and the suction pressures by mercury manometer; there was always a slight pressure in the suction pipe at its centre line. Both readings were taken every five minutes, the discharge gauge being carefully calibrated.

The specifications required that the water pumped should be measured by Venturi meter, and both of the pumps discharged through a 36-inch meter with 21-inch throat. The quantity was calculated from readings of a mercury manometer, using the coefficient supplied by the Builders Iron Foundry, the makers of the meter, who state that a manometer reading of 5.07 inches of mercury corresponds to a discharge of 25.30 millions of Imperial gallons daily.

Readings were taken on the manometer at five-minute intervals, and in order to check the recorder for the meter, readings were also taken on it, and the results included for reference.

The contractors for the units were the Turbine Equipment Company, Toronto, who were represented by their manager, Mr. Austin, and also by Messrs. Salt and Petersen of the De Laval Turbine Company, Trenton, who designed the machinery and built much of it. The writer represented the city of Toronto and personally conducted both the trials.

Remarks on the Trials.

The results obtained on the units are a matter of great satisfaction, partly because they have so far exceeded the guarantees of duty, and partly because the results are exceptionally high for this class of pumping unit, and have probably not ever been exceeded by any similar unit running under similar conditions of steam and of equal water pressures.

General Dimensions of the Units.

(Both are exactly alike.)

Turbine.	
Normal speed .....revs. per min.	3,430
Diameter of steam pipe .....in.	4.5
Diameter of exhaust pipe .....in.	36
Double Helical Reduction Gear.	
Number of teeth in pinion	33
Number of teeth in gear	197
Ratio of teeth	5.97
Pump speed corresp'd'g to turbine speed above	575
Pump.	
Number of stages	2
Suction and discharge openings .....in.	24
Suction inlet to condenser .....in.	42
Size of city's discharge main .....in.	36
Enlarger from pump discharge to main ....in.	24 x 36
Rated speed .....revs. per min.	575
Air Pump—Wheeler Rotrex.	
Size .....in.	20 x 40
Size of direct coupled driving engine .....in.	7 x 7
Rated speed .....revs. per min.	200
Feed Pump—Goulds Triplex Single Acting.	
Size of plungers .....in.	3½ x 6
Speeds in the two units .....revs. per min.	47 & 66

Results of Duty Trials.

	Westerly unit.	Easterly unit.
Average barometer reading ....in.	30.06	29.43
pounds per sq. in.	14.77	14.45
Pressures and Temperatures.		
Average boiler pressure—pounds per sq. in.	149.4	148.4
Steam pressure at the turbine—pounds per sq. in.	144.7	144.6
Pressure in the calorimeter—pounds per sq. in.	1.36	1.38
Temperature in the calorimeter—deg. F.	294.8	300.2
Moisture in steam at turbine—per cent.	0.66	0.35
Vacuum in exhaust chamber—in. .	29.33	28.69
Temperature of steam in exhaust pipe—deg. F.	60.3	61.9
Water Pressures.		
Suction pressure as read—pounds per sq. in.	0.89	1.19
Delivery pressure near suction pipe level—pounds per sq. in.	107.34	107.97
Difference of gauge levels reduced to—pounds per sq. in.	0.79	0.40
Net pressure produced by pump—pounds per sq. in.	107.24	107.18
Net pressure specified—pounds per sq. in.	107.0	107.0
Quantity of Water Pumped.		
Size of Venturi meter tube—in. ...	21 x 36	21 x 36
Average manometer reading—in. mercury	4.895	4.99
Corresponding discharge—millions of Imp. gals. per 24 hours....	24.86	25.10
Specified discharge—millions of Imp. gals. per 24 hours.....	24.00	24.00
Dial on recorder gave—millions of Imp. gals. per 24 hours	24.80	24.99
Speeds.		
Average pump speed—r.p.m.	582.6	574.8
Corresp'ding turbine speed—r.p.m.	3,478	3,431
Average air pump speed—r.p.m. ..	151	147
Feed pump speed, double strokes each plunger	66	47
Water Horse Power.		
Net pressure produced by pump—pounds per sq. in.	107.24	107.18
Discharge—million Imp. gals. per 24 hours	24.86	25.10
Work done per hour—foot-pounds: Westerly unit .. 2,562,679,427 Easterly unit .. 2,585,972,052		
Corresponding water horse-power.	1,294.3	1,306.0
Steam Used per Hour.		
Steam condensed during test, including drips—pounds	169,803.5	168,010.0
Steam used per hour—pounds	16,980.3	16,801.0
Steam used per water horse-power hour—pounds	13.14	12.88

Duty.	Westerly unit.	Easterly unit.
Work done per hour—foot-pounds:		
Westerly unit .. 2,562,679,427		
Easterly unit .. 2,585,972,052		
Steam used per hour—pounds	16,980.3	16,801.0
Duty obtained—millions of foot-pounds of work per 1,000 pounds steam used	150.92	153.92
Duty specified	141.5	141.5
Amount that the unit exceeded the guarantee under specified conditions—millions of ft.-pounds	9.42	12.42

CANADIAN ENGINEERS BLEW UP HILL 60.

In a special dispatch from the Front, the Toronto Evening Telegram a few days ago published the following item concerning the work of Canadian engineers:—

"Hill 60 went up in fine dust, and well it might, for 250 tons of aminol, an explosive four times as violent as dynamite, had been stored away beneath this hill, notable in the struggles which have been waged in the Ypres salient.

"The engineering operations were performed by No. 3 Tunnelling Company, Canadian Engineers. There were three tunnelling companies with the Canadian forces who held this front until last summer, when they were moved to the Somme front. So well did they do their work that, when the Canadian army moved south, the tunnelling companies were made Imperial army troops, and remained. The charges that yesterday blew up Hill 60 were placed as long ago as last October.

"How Canadian ingenuity and pluck 'beat the Hun' in the operations in this sector is a story that cannot be told until the war is over. Meantime, give credit to the men who, 25 to 120 feet below the earth's surface, stripped to the waist, dig and 'kick' their way in tunnels about 2½ by 4 feet toward the enemy line. Under Hill 60 they encountered blue clay, the hardest of all soil to get through. And if the tunnellers clash with an enemy party, they do it in the dark and with knives."

A reinforced concrete water tower recently completed at North Point, Ala., has an 80,000 gallon tank 30 ft. high and 22 ft. in diameter, supported on a single centre column 35 ft. in height. The column has an extended conical base to provide stable footing and is hollow, containing the supply and discharge pipes for the tank above.

The British Trade Commissioner in Australia (Mr. G. T. Milne) recently forwarded to the Board of Trade Department of Commercial Intelligence, London, England, an extract from the local press containing a report by the manager of the Tasmanian government hydro-electric undertakings concerning further projected schemes. In addition to the Great Lake and King River schemes, it is stated that others are likely to be put in hand. There will be no difficulty in developing on the West Coast itself all the power needed there, even if the demand grows much larger than is at present anticipated. Over 10,000 horse-power can be developed at Lake Rolleston, near Zeehan, and the Franklin River, and other possible sources of power are now being prospected. Later, when copper is cheaper, an inter-connecting wire may be run from the West Coast to the Great Lake. In the central plateau region several schemes, quite apart from the Great Lake, are now being inquired into. It is thought that 40,000 horse-power—possibly more—can be developed on the River Derwent; the works will probably be some distance below Lake St. Clair, which will serve as a reservoir. The Arthur Lakes are a source which seems well able to yield 40,000 to 50,000 horse-power.

LUBRICATION OF ROCK DRILLS.*

By Charles C. Phelps,
of the Ingersoll-Rand Co., New York City.

ROCK drills are generally regarded as the most "rough and ready" tools in use. They can withstand almost any abuse. As a consequence, many drill runners believe that any oil is good enough for lubricating a drill. While it is true that drills will run with almost any kind of oil, it is beyond question that the best results and the least repair costs are obtained only by employing lubricants especially suited to the service. For steam-operated drills a good quality heavy-body steam cylinder oil is generally found to be most suitable. For air-operated drills, the usual advice is to employ a light or medium-body oil of good quality; however, recent experiments have shown that liquid grease is much better suited for air-operated drills under many conditions of service. This lubricant has been used successfully with both hammer and piston drills, mounted and unmounted types. Liquid grease is particularly valuable for water machines, like the Leyner-Ingersoll, water jackhamer and water stope-hamer, for the reason that it is not washed out by the water as readily as oil is.

Liquid grease is a substance that has the appearance of oil and flows similarly, but otherwise has the characteristics and properties of grease. It may be handled in an ordinary oil can and will flow freely through the automatic lubricators on drills. It is made by several of the oil companies. It would be impractical to list here all the various brands which are suitable for air-operated drills, but "1 R X" Jackhamer and Stoper grease (Standard Oil Co.), No. 6 Keystone liquid grease (Keystone Lubricating Co.), and "B" absorbed oil (E. F. Houghton & Co.) have been found to give satisfactory results.

The method of feeding is fully as important as the kind of lubricant used. Insufficient lubrication results in slower drilling speed, power wasted in friction, and a more rapid wearing out of parts with consequent higher repair expense. Lubricating too liberally simply increases the oil bill without making any appreciable gain in the operation of the drill. Too often, the matter of lubrication is left to the discretion of the drill runner, who either feeds the oil too liberally or forgets to replenish the supply until the drill runs dry and, by its poor performance, reminds him that it is time to relubricate. One of the best ways to determine whether a hammer drill is getting sufficient lubricant is to notice, when changing steels, whether the shank has oil on it. An operator soon learns to tell when a drill needs lubricant by the dry appearance of the steel shank.

The more modern drills are provided with means for automatic lubrication—features of the greatest practical value. Sometimes the oiling device is an integral part of the drill, and sometimes it is a separate part.

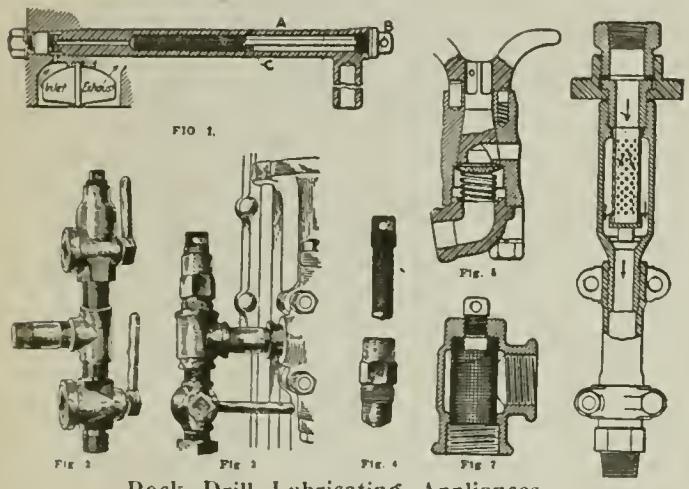
Fig. 1 shows the arrangement for oiling employed with a typical stoping drill. The oil well is in the handle used for rotating the stoper. The hollow handle *A* fits in a taper hole in the valve chest. In the handle is a porous plug *C*, beyond which is the oil chamber. Before starting the machine, oil plug *B* is removed and the chamber in the handle filled with liquid grease. As the machine runs, the pulsations of the air in the supply chamber of the chest draw the oil through the porous plug into the machine. Means are provided to exhaust any pressure in the handle after the air is shut off without

*From "Engineering and Mining Journal," New York.

drawing the oil out of the chamber. The porous plug serves the double purpose of regulating the flow of oil and straining out any dirt or grit it may contain. A somewhat similar arrangement is used with jackhamers, but in these drills the oil chamber is placed in the side of the cylinder.

If a drill does not embody an oiling device as an integral part of its construction, it can be fitted easily with a special oiler, of which there are several types on the market. In fact, many modern drills are designed to be used with oilers of the external type.

Fig. 2 shows a satisfactory type of external oiler which embodies an oil reservoir of about a half-pint capacity. It is made of malleable iron with a taper plug valve, and is intended for use with either air or steam-operated piston drills. The reservoir is closed with a screw plug. The taper plug has two cups on opposite sides, each holding about a teaspoonful of oil. One cup is always in communication with the reservoir and filled. A half-turn of the handle empties this cup into the supply passage to the drill, and the oil is carried as a spray into the machine. The other cup is filled ready for another



Rock Drill Lubricating Appliances.

Fig. 1—Handle of a stoping drill used as an oil reservoir. Figs. 2, 3 and 4—External oiler and lubricating cartridge. Figs. 5, 6 and 7—Three types of oil strainers in use with water drills.

turn of the handle. The reservoir holds enough oil for a half-shift's run, and the handle should be thrown about every 5 to 10 ft. of drilling. The right amount of oil is admitted each time, with no loss of oil or pressure.

Another type of oiler, Fig. 3, is designed to take the responsibility for proper drill lubrication out of the hands of the runner and place it entirely in those of the foreman. It operates by the pulsations of air in the supply pipe near the drill, due to the alternating reversals of the drill piston, and from the nature of its operation has been aptly named the "Heart Beat" oiler. It consists of an oiler body containing a plug carrying a cartridge of wire gauze and an absorbent material (Fig. 4). The body is screwed into a tee, to the branch of which the drill is connected, the oiler coming above the tee and the throttle.

The cartridges are carried in boxes. Three cartridges will suffice for one shift. The drill runner going on shift gets three cartridges from the foreman, and coming off shift, he returns three dry cartridges, which are dropped in a tub of oil and recharged. There is no way of drying the cartridges except by using them in the drill, and the return of dry cartridges is proof the drill has been properly oiled. The oil is not wasted—blown out without doing useful work—but is fed slowly and used to best advantage.

The "Heart Beat" oiler not only enforces proper lubrication of the drill, thus reducing its wear and increasing its capacity, but also economizes lubricant. This type of oiler is intended only for use with air-operated piston drills.

Sometimes drill runners introduce oil through the hose, pouring it in before connecting the drill line to the pressure main, thereby saving themselves the trouble of unscrewing the oil plugs of the drill. This practice cannot be condemned too emphatically, for the oil rapidly destroys the rubber lining used in ordinary hose, and furthermore, it carries into the drill any particles of dirt that may have lodged in the hose.

The remaining important point to be considered in connection with lubrication pertains to grit, dirt and other foreign matter. It is scarcely necessary to mention that the working parts of the drill should be cleaned frequently, preferably with kerosene, and kept well oiled or greased while standing idle.

Dirt must be prevented from entering the drill either with the lubricant or with the compressed air. The former point is taken care of by using a good quality of liquid grease only or oil free from impurities and keeping the supply in a closed vessel. A little grit will do a lot of damage in cutting out cylinders, valves and rotation parts. Small particles of grit and dust pass through the hose, and these must be removed before entering the drill, usually, by an air strainer or filter of some type placed as close to the drill inlet as practicable.

Fig. 5 shows the details of a strainer placed within a stoping drill. This strainer consists of a cup-shaped disk of perforated metal held in position back of the throttle valve by a coiled spring. It has been objected by some that a strainer such as this will result in loss of air pressure. However, tests at various pressures have shown that no reduction in air consumption or loss of power occurs through its use. If the work done by the machine falls off, it is an indication that the strainer is clogged with dirt and needs cleaning. It will be noticed that the air inlet is enlarged at the strainer, permitting an unrestricted flow of air.

Fig. 6 shows another type of strainer, which is principally intended for use on stope drills. The straining medium consists of a piece of perforated metal rolled into the form of a tube. The connection of which this type of strainer is a part should always remain attached to the valve chest when the machine is disconnected from the pressure line to prevent dust from entering the tool while lying idle. Dirt collects on the inside of the straining tube and may be easily removed from time to time by taking the device off the drill and blowing air through it from the end opposite that into which air ordinarily enters. Fig. 7 shows a sectional view of an angle filter, which forms a part of the standard equipment of certain water drills.

The straining medium in the filter illustrated in Fig. 7 consists of a tube of brass wire cloth through which the air must pass to enter the machine. The area through this tube is greatly in excess of the area of the inlet and outlet passages, which insures a free flow of air.

The production of graphite in the island of Madagascar, in 1915, amounted to 15,000 tons, compared with 8,000 tons in 1914, 6,319 tons in 1913, and 1,500 tons in 1911. Because of the large demand for this mineral in France and England, the local government has called upon the producers throughout the island to increase their output, and it is believed that the production for 1916 greatly exceeded 20,000 tons.

OUR WAR PROBLEMS.

(Continued from page 518.)

any other country on the face of the globe. We have some 35,000 miles of railway for a population of about eight million people.

A most interesting and valuable report on this problem was prepared by Mr. W. F. Tye, one of our members, who is also a member of the American Society of Civil Engineers. He presented his report in the shape of a paper read before one of the semi-monthly meetings of the Canadian society at Montreal. We did with it as we do with all of our papers,—printed it and distributed three or four thousand copies to our members, in addition to which Mr. Tye himself had printed and distributed about three thousand copies; so that as a result, before this debate comes off in parliament the people as a whole will have been well informed as to the existing conditions in regard to our railways and as to the possible methods of solution suggested through this paper.

Engineers in Canada have been called upon to advise and take certain part in the solution of many of the great war problems that we are now facing.

When we speak of Canada as it is to-day and of Canada as we hope it will be in the near future, it is impossible to disassociate the subject from Canada's part in the war, and as your chairman has seen fit to include my name in the program to speak on "War problems," I would like to approach the subject in that way, and particularly from the standpoint of the part which has been played by Canada.

War to-day is a matter of science. We can all look back to the times when we grumbled a great deal at being forced to read the history of how certain of the ancient armies went out to battle each other with battle-axe or broad-sword, or following on down through the more modern stories of war, but none of our studies have given us any appreciation of the change which has taken place in the conduct of war in the last few years.

The appliances used in connection with war nowadays are wholly a matter of engineering science. Whether it is a question of air-craft, submarines, high explosives, guns, projectiles, rifles, "tanks," or motor power, or particular kind of trenches and protective works; through the whole list you will notice that the engineering profession in some branch comes into play. Beginning with high explosives, you know the change which has taken place through the investigations of chemical engineers, until to-day the explosives used in warfare differ entirely from those used fifty years ago.

In the matter of guns: to-day the methods used in manufacturing guns (I mean when I speak of "guns," of course, artillery), are based upon different principles, and their use is entirely different from previous wars. Our modern rifles are entirely different and hundreds of new mechanical appliances are being used, so that it may be claimed that war to-day brings into play a greater number of engineering activities than was ever dreamed of in past wars. As a consequence, throughout all the armies of all the warring nations the engineer is playing a very prominent part.

As president of the Canadian Society of Civil Engineers, I am proud of the fact that we are putting up in our home building a roll of honor of the men in the engineering society in Canada who have gone to the front. That roll will comprise over 700 names. We are putting it up in the main hall of our building with a proper inscription, containing the name and rank of every man who responded to the call. Unfortunately, already we are having to signify many of the names on that roll with a golden star, showing that these men have made the supreme sacrifice for the good of the country and their profession.

When we came to the great demand for guns and munitions resulting from the changed method of warfare, very few people knew anything about it outside of Germany or France. Great Britain knew little about it and on this continent we knew nothing about it. You have in the United States, government arsenals that make munitions for your own guns, but they were not the character of munitions used in Europe. They would have been useless in the character of campaigns carried on there now, and therefore both in the United States and Canada in the effort to meet the demand it was necessary to originate entirely new methods, and the success met with is largely due to the way in which the mechanical engineers responded to the call, and took charge very largely of the installations in the munition plants which sprang up almost over night. As a result, in Canada to-day we have some four hundred thousand people engaged in the manufacture of munitions, largely of explosive munitions. We have had to create an entirely new equipment, but we have been able to get to that stage that with the marvelous expansion in Great Britain in the same lines, it looks as if in the near future we will be able to manufacture most of our own munitions. May I suggest to you, gentlemen, that the mechanical, civil and chemical engineering societies of the United States should put their services to-day at the call of your government?

In conclusion, gentlemen, the attempt to speak to you of the war problems is, of course, a very big undertaking. I have only in a very disconnected way attempted to tell how the profession that we are all proud to belong to has played its part. Some of the most important actual service done by men at the front has been done by men of the engineering profession.

Finally, I would say to you that the war is bound to affect you as it has us. It is bound to affect you as citizens; it is bound to affect your profession. There is no doubt but that following the war there is going to be a great demand for engineering experience the world over. Great Britain has suffered an immense loss in men, ships, material and wealth, but her shores have not been invaded nor are they likely to be. On the continent of Europe, the destruction is beyond human comprehension; and in connection with rehabilitation of these countries, engineers will be greatly in demand. In Russia, the opportunities after the war are going to be very marked. Russia is a marvelous country. The new government will probably follow a much more progressive policy and do much to extend the development of that country. There are Russian commissions now looking after industrial construction, dock installation, elevator construction, along the most detailed lines of costs, and supplies of material, which, if carried out, will involve an expenditure of many million dollars. Then, in France and Belgium there will be great openings for engineers, and it is reasonable to suppose that the engineering professions of the country who take part in the war will have the first call. We think that the men of the engineering profession in Canada who responded to the call of duty are going to have the first call in a professional way in the rehabilitation of these countries.

The largest octagon ingot mould which has ever been cast in America, and perhaps in the world, has recently been made by the Bethlehem Steel Company. It is said to weigh nearly 140 tons.

MANUFACTURERS DISCUSS RAILWAYS.

The necessity for additional railway equipment was brought strongly before the annual meeting of the Manufacturers' Association in Winnipeg last week by the report of the transportation committee. Attention was called to the recommendation of A. H. Smith, president of the New York Central Railroad, in the minority report of the railway commission, that the government should undertake at once to provide for an ample supply of freight cars and locomotives against immediate and imperative needs. The committee urged that the convention should make some representations to that effect to the government.

The valuable work done by the committee in connection with freight rates and other railway matters of prime importance to manufacturers was set out at length in the report. Commenting on the findings of the Royal Commission appointed to inquire into railways and transportation in Canada, the committee emphasized the unnecessary duplication of railway lines and facilities throughout the country and contended that legislation was absolutely necessary to guard against such evils in the future and to protect investments already made.

U.S. GOVERNMENT WILL BUILD ARMY TOWNS.

The training camps for the United States army will be complete small cities. Each will cover an area of 720 acres, will contain some 2,000 buildings, water supply and sewerage systems and roads. All will be built by contract. Most of the buildings will be long one-story structures of wood. The contractors will organize their own forces, but the building will be under the direction of army officers. Sites for the camps are now being selected and plans are ready for awarding contracts as fast as camp sites are chosen. Col. I. W. Littell, of the Quartermaster Grounds Division has been placed in general charge of cantonment construction.

CANADIAN ELECTRICAL ASSOCIATION.

The 27th annual meeting of the Association was held at the Ritz-Carlton Hotel on June 7th and 8th. According to statements made, Montreal has the cheapest electrical power of any industrial centre in America, this being due to the fact that there is an abundance of water power near the city.

A paper on "Electro Chemical Products" was read by H. E. Howe, and another on "Energy Distribution, Present and Prospective," by Julian C. Smith, Vice-President and Chief Engineer, Shawinigan Water & Power Co.

TORONTO ENGINEERS VISIT CAMP BORDEN.

About thirty members of the Toronto Engineers' Club motored to Camp Borden on Tuesday, June 12th. The start was made from the corner of St. Clair Avenue and Yonge Street about 8.30 a.m. Upon reaching the Camp the party was escorted by members of the Flying Corps, during an inspection of the hangars and aeroplanes. Lunch was served in the officers' mess. The party left Camp Borden about 6 o'clock and reached Toronto about 10 o'clock after a most enjoyable day's outing

It was stated during the last annual meeting of the Canadian Electric Railway Association that on June 13th, 1916, there were 1,417.62 miles of privately-owned electric railways in Canada.

Reports of recent meetings of the Channel Tunnel Company indicate that the British government will likely decide that the much discussed tube connecting Great Britain and France shall be built. There have been repeated rumors recently that the decision would be favorable. At the meeting Baron Derlanger declared that some move must be made soon one way or the other, for railways preparing to rebuild the portions of their line on the Channel coast must know where the tunnel would begin on the English side.

DOMINION STEEL CORPORATION'S REPORT.

The net earnings of the Dominion Steel Corporation for the year ended March 31st, 1917, were $12,067,874, as compared with $7,004,310 for 1916. After adding $3,000,000 to a special reserve, and paying all charges and divdends, a balance of $6,038,182 is carried forward at credit of profit and loss.

The balance sheet shows current and working assets at the end of the year as $15,446,396. These included $4,858,167 in cash and $1,085,671 in war loans. The only current liabilities to set against them were $1,572,530 in ordinary trade accounts payable, wages, etc.; $246,731 for interest accrued on bonds, and $495,977 for dividends declared, payable after the close of the company's year—a total in all of $2,315,238. Total assets amount to $83,526,822.

President Mark Workman in the report states as follows: "The aggregate reduction in the funded and mortgage debts of the corporation and the constituent companies during the year was $5,501,700. The most important measures for extension and improvement are the construction of two batteries of Koppers By-Product Coke Ovens and extensive development of the iron ore mines in Newfoundland, both of which will strengthen the position of the corporation in respect to the output of iron and steel. The production of all the coal company's collieries was considerably below that of recent years, amounting to 4,279,772 tons, against 5,261,198 in 1916, 4,550,512 in 1915, 5,047,683 in 1914, and 5,051,603 in 1913. The causes of this falling off were beyond the control of the directors, arising for the most part from the scarcity of men consequent upon enlistment for service overseas, and also to a considerable extent from the lack of adequate transportation facilities."

New records were made by the steel company. The tonnage of pig iron produced exceeds the output in any previous year; as also does the output of steel ingots. The following table gives the annual production of the principal classes of iron and steel materials in the last two years:—

	Year ended Mar. 31, 1917.	Year ended Mar. 31, 1916
Pig iron	346,926	329,664
Steel ingots	377,079	371,086
Bloom and billets for sale..	144,051	142,282
Rails	17,495	35,197
Wire rods for sale	67,492	55,106
Bars	5,259	8,017
*Wire	35,142	36,058
Nails	20,175	10,262

*This includes wire used in manufacture of nails shown in next line.

PARSONS FAVORS NATIONALIZATION.

That the railways in Canada should be nationalized was the contention of Mr. S. R. Parsons, vice-president of the Canadian Manufacturers' Association, when addressing the Hamilton branch recently. Five years ago, he said, he was opposed to such a project. He now believed that the nationalization of railways was a measure that would prove productive of much good. Since the outbreak of war the demagogue and the demagogue's regime was over, and only big men would be able now to secure seats in parliament—men big enough to operate successfully the railways of this country.

Mr. Cyrus A. Birge, in moving a vote of thanks to Mr. Parsons, said he did not favor the nationalization of railways. He had never heard of a country that was successful in managing its own railways, nor did he think he ever would.

Mr. T. S. Dickson, of William Beardmore & Company, shipbuilders, Glasgow, is in this country for the purpose of selecting a site for an extensive steel shipbuilding and dry dock plant. It has been definitely settled that a plant will be built in Canada. In company with Mr. A. D. Swan, consulting engineer, Montreal, Mr. Dickson has inspected sites at Montreal, Quebec, Halifax, N.S., and St. John, N.B.

Editorials

LAKE OF THE WOODS LEVEL.

From the summaries which have been given out simultaneously at Ottawa and Washington of the final report of the International Joint Commission, the problem of the proper level for the Lake of the Woods appears to have been settled in a manner most satisfactory to Canadian engineering interests. The commissioners have recognized that the dominant interests in that region are those relating to hydro-electric power.

The level set by the commission—from 1,056 to 1,062.5, sea-level datum,—is a higher level than that desired by the farmers bordering the lake, and means that the lake primarily will be used as a storage reservoir for the Winnipeg River and other water powers. The highest known level previous to 1916, as shown by the rocks around the lake, was 1,062, sea-level datum. This is higher than any level reached since 1892, the year when the levels were first taken and reported. In the spring of 1916, the lake reached 1,064 for a short period, but that flood was unusual and not likely to recur very often.

The maximum established by the commission is therefore within 0.1 ft. of the highest known level with the exception of last year's flood, and is higher than any level reached since 1892. This means that the importance of the development of power has been fully recognized. The farmers whose lands will be flooded will be compensated by cash payments.

One of the questions incidental to establishing a proper level for the Lake of the Woods, and one which for a time threatened to overshadow the main problem itself, was in regard to the control of the Norman Dam. This was a matter which involved principle and public policy and which necessarily had to be considered by the commissioners of the respective countries upon national as well as international grounds.

The question was whether there should be Canadian or international control of the Norman Dam,—a structure on the Winnipeg River which, while wholly in Canada and some sixty miles to the north of the international border, has a bearing upon international problems because it is the chief means of controlling the level of the Lake of the Woods.

This question has been most satisfactorily settled by naming 1,061.25, sea-level datum, as the ordinary maximum stage. So long as this height is not exceeded, control remains with the Ontario government, co-operating with the Dominion government. But should the water rise above the ordinary maximum or fall below 1,056, it is deemed that international interests would be affected and control then would be temporarily exercised by the International Joint Commission.

POLITICS AND BUSINESS.

The secrets of the political rules and regulations are confined to the select few. They have helped to prevent a coalition government. Yet strong opinion, thinking independently of parties, favors a national business government. Should Sir Robert Borden reconstruct his cabinet, choosing men of business ability for that reason and not for party reasons, the country will support him. Only professional politicians, who have been trained to look at everything from the partisan viewpoint, will protest against the breaking of ancient precedents at Ottawa. A determined effort to utilize all the available energy, money, brains and material, irrespective of party leaning, will have the country's approval.

Our people desire the nation's affairs and its part in the war conducted as large, enterprising corporations carry on their work. The Canadian Pacific Railway, the T. Eaton Company and other such institutions appoint their directors and executives with a view to getting the best results and to giving good service in the shortest time and with the least possible expenditure. These days of crises demand that governments should adopt the best business methods in the work of their administrations.

CANADA'S FUEL COMMISSIONER.

Members of the Canadian Society of Civil Engineers will be much gratified that one of their number has been selected by the government for the responsible position of fuel commissioner for Canada. Charles Alexander Magrath, D.T.S., M.Can.Soc.C.E., was born at North Augusta, Ont., in 1860. From 1878 to 1882 he was assistant on base lines, principal meridians and astronomical surveys for the Dominion Government. From 1882 to 1885 he was in charge of the government astronomical surveys. In 1885 Mr. Magrath left the employ of the government and became engineer for the Northwestern Coal & Navigation Co., and later on manager of the company's irrigation developments. After 21 years' connection with that firm, he was elected a member of the Dominion Parliament, and in 1911 became one of the three Canadian commissioners on the International Joint Commission. In 1915 he was elected chairman of the International Joint Commission, which important post he still occupies. Last week he was named by Premier Borden as fuel commissioner for Canada, with full authority to regulate sales and distribution of fuel throughout the country.

It is perhaps unusual to relate a biography editorially, but the circumstances deserve unusual treatment, because it is most unusual for any Canadian government, either liberal or conservative, to recognize an engineer for an important government appointment of this character, involving a high degree of executive skill and diplomacy. Mr. Magrath has shown a most satisfactory record and this should be an incentive to the government to try some more civil engineers for similar positions. His broad-mindedness and far-sightedness are general characteristics of all engineers perhaps to a greater extent than applies to any other body of professional men. His resourcefulness and energetic method of getting things done thoroughly without undue delay is also typical of all the successful engineers. Premier Borden could find more C. A. Magraths among the members of the Canadian Society of Civil Engineers if he cared but to look for them.

The attitude of professional politicians toward engineers is well exemplified by the fact that one well-known member of parliament thought it necessary to apologize to his fellow statesmen in 1911 for the selection of an engineer as a member of the International Joint Commission, saying that Mr. Magrath was appointed "because of his keen, judicial mind."

PERSONALS.

Gunner J. DONALD McFARLAND BEATTIE, of Montreal, a graduate in Applied Science of McGill University, was wounded in the arm by gun shot on May 28th, and is now reported to be convalescing in a hospital in England.

S. B. BENNETT, formerly municipal engineer of South Vancouver, has been appointed principal of engineering and allied trades at the Winnipeg college for returned soldiers.

Lieut. FRED CLARKE, engineer and contractor, who has been connected with Grant, Smith & Co., of Vancouver, for the past few years, is organizing a railroad construction draft for overseas duty.

V. H. EMERY, formerly underground superintendent of the Hollinger gold mines, Timmins, Ont., has obtained a commission as lieutenant in the Royal Canadian Engineers.

CHARLES B. GORDON, vice-chairman of the Imperial Munitions Board, has resigned his position to become attached to Lord Northcliffe's mission to the United States. He will act there as representative of the British minister of munitions.

F. P. GUTELIUS, Jr., son of F. P. Gutelius, formerly general manager of the Canadian Government Railways, Moncton, N.B., was graduated from Lafayette College, Easton, Pa., on June 11th, and received his degree in Civil Engineering in absentia. He is now in the Canadian army.

HERBERT JOHNSTON, A.M.Can.Soc.C.E., formerly city engineer of Kitchener, Ont., has commenced practice in Kitchener as a consulting engineer.

SAMUEL KING, of London, Ont., has been appointed managing-director of the National Steel Car Co., Limited, of Hamilton, Ont., in place of BASIL MAGOR, who recently resigned. T. O. SCOTT, formerly secretary of the Canadian Tungsten Lamp Co., of Hamilton, has been appointed secretary-treasurer.

R. W. KNIGHT has severed his connection with the Standard Steel Construction Co., Welland, Ont., and will soon return to the United States.

Brigadier-General F. O. W. LOOMIS, of D. G. Loomis & Sons, contractors, Montreal, and Major E. G. M. CAPE, president of E. G. M. Cape, Limited, contractors, Montreal, are among the Canadian officers' names submitted by Sir Douglas Haig as deserving of special mention. Both officers were also included in the King's birthday honors. Brigadier-General Loomis has been made a C.M.G. and Major Cape has been awarded the D.S.O.

S. R. PARSONS, of Toronto, president of the British-American Oil Co., Limited, and of the Toronto Iron Works, has been elected president of the Canadian Manufacturers' Association for the next twelve months.

Sir WILLIAM D. REID, president of the Reid-Newfoundland Railway, and J. K. L. ROSS, a director of the C.P.R., have been elected directors of the Dominion Steel Corporation.

Hon. P. J. VENIOTA, minister of public works of New Brunswick, is ill in a Fredericton hospital.

FREDERICK S. VINEY, formerly with Westinghouse, Church, Kerr & Co., New York City, has assumed charge of the electrical department of F. R. J. MacPherson Co., Limited, Peterborough, Ont.

THOMAS WILLOUGHBY has been appointed chairman of the board of works, Owen Sound, Ont.

OBITUARIES.

SIR ALEXANDER R. BINNIE, an eminent engineer, died May 18th at Beer, Devon, England, in his 75th year. He was president of the Institute of Civil Engineers in 1905-6, president of the Institute of Municipal and County Engineers in 1897-8, and a member of the Royal Institute. He carried out important public work in India and held the position of chief engineer to the London County Council from 1890 to 1902. In February, 1913, along with Dr. A. C. Houston, of the London (England) Metropolitan Water Board, Sir Alexander visited Ottawa to report on an improved water supply for that city. Sir Alexander, after a thorough investigation of the conditions, recommended that the existing source of supply from the Ottawa River be abandoned and that what is known as the "Thirty-one Mile Lake Scheme" be adopted. This scheme met with the approval of the provincial board of health for Ontario, but the citizens voted against it and in consequence no further action has been taken.

SIR WILLIAM CHRISTOPHER MACDONALD, chancellor of McGill University, Montreal, died on June 9th after an illness extending over a period of three years. Sir William was born in Prince Edward Island in 1831. He was one of the eight honorary members of the Canadian Society of Civil Engineers, having been so elected on January 9th, 1896, on account of his outstanding assistance to the cause of engineering through McGill University. His aid in money to McGill totalled $10,090,165, a large portion of which comprised property, buildings and endowments for engineering, architectural and chemistry departments. Sir William Peterson, head of McGill University, often said that he was ashamed to go to Sir William Macdonald so often for money, but that the latter was always ready with open hand. Sir William Macdonald laid the foundations for his large fortune in the tobacco trade, and was long known as the "Tobacco King" of Canada. He had many interests and profitable investments aside from his own business, however.

JAMES WARREN, civil engineer and land surveyor, died at Walkerton, Ont., on June 11th, after a brief illness. Mr. Warren, who was in his 80th year, was born in the county of Halton, near Acton, and for many years was the official engineer for the counties of Halton and Bruce. In 1870, under contract with the Dominion government, he sub-divided into townships a section of the province of Manitoba, and in subsequent years performed a similar service in Saskatchewan and Alberta. His last contract was filled in 1910, when he sub-divided a section of Alberta lying among the foothills of the Rockies.

GEORGE A. STEWART, who was for some years city engineer of Calgary, Alta., passed away at his home in Victoria, B.C., on May 13th, at the age of 87 years. He was the fourth son of the late Hon. Thomas Alexander Stewart, and studied civil engineering under Sir Sanford Fleming, later assisting in the construction of the first railway built in Canada. He practised his profession at Port Hope until 1867 and was chief engineer of the Midland Railway from 1868 to 1877. A large wooden pontoon bridge built by Mr. Stewart, the first bridge of its kind erected in Canada in 1866, is still in service. For eleven years, from 1886, Mr. Stewart was in charge of the Rocky Mountain National Park, and later went to Calgary, where he resided a number of years and served as city engineer. He removed to Victoria about eight years ago, having retired from active practise of his profession. Mr. Stewart was a member of the Canadian Society of Civil Engineers.

The Canadian Engineer

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STREET IMPROVEMENT IN ONTARIO

Provincial Department of Public Highways Presents Detailed Report on Paving Work in Twenty-Two Cities and Eleven Towns, Covering 2,291 Miles of Streets, of Which Only 628 Miles, or 27.41%, Are Paved

ONTARIO'S Department of Public Highways has just published a report on street improvement which contains information procured by a survey of twenty-two cities and eleven towns. The report is intended to assist the smaller municipalities in their paving problems. A great amount of money has been misspent or wasted, says the report, due to lack of experience and proper advice and guidance in the undertaking of schemes for street improvements, and the hope is expressed that this publication may present information which will prevent such mistakes from being repeated.

In the introduction, W. A. McLean, Deputy Minister of Highways, outlines the growth of city streets from the country corners of several generations ago to the modern urban thoroughfare of to-day. The expenditure involved by street improvement is discussed and he condemns the mistake of undertaking work of this nature without consideration of a general plan. Lack of intelligent and experienced supervision also accounts for much of the expenditure of public funds for which no adequate return is received.

The location of main thoroughfares with the possible growth of the municipality in view and the proportioning of these highways to suit not only the present but the future need of the community are phases of the work that demand careful study. The selection of the type of pavement best suited to local conditions, is of great importance. There are a number of factors that should govern this selection, the chief of which are: the size and wealth of the municipality; the amount and class of traffic on the street under consideration; the class of street, whether business, residential, etc.; and the materials available locally for use in the construction of road surfaces.

Then follows a discussion of the selection of materials for the different types of construction, covering all classes of pavements from the gravel or broken stone surface to the most durable as well as the most expensive forms, such as creosoted wood block, brick and stone block. These descriptions are illustrated by drawings. Streets of cities, towns and villages are classified, and the materials best suited to the construction of these are shown under the different headings.

Park Avenue, Sandwich, Ont.

Cited by the report as an excellent example of artistic treatment of city street.

High Park Boulevard, Toronto, Ont.

Cited by the report as an excellent example of artistic treatment of city street.

The treatment of gravel and macadam roadways with oils and tars is described; the advantage of rounded corners at intersections in order that motor traffic may turn easily and safely is illustrated; the paving possible in avoiding land damages by the establishing of permanent grades and street levels in new subdivisions is shown; and the two important items of drainage and foundations are discussed.

The second portion of the report describes in detail street improvement in twenty-nine of the municipalities throughout the province. The history of street improvement from the laying of the first roadway is given, and the methods used in the construction of pavements, sidewalks, curbs, gutters, street railway track

allowances and pedestrian crossings. Detailed costs of materials, labor, pavements, sidewalks, curbs and gutters are furnished. Special features such as the construction of bridges, subways, driveways, etc., are fully described and the costs of these various works supplied where possible.

The index is complete, showing the subjects discussed under the names of the municipalities as well as in their general alphabetical order. In addition to being a report, interesting and instructive, it will prove a valuable book of reference to those connected with street improvement. It contains 200 pages, 100 illustrations and a colored frontispiece showing three examples of the artistic treatment of urban thoroughfares.

Method of Compiling Report.

In order to obtain full and accurate information with respect to street improvement in the province, nineteen of the cities and ten of the larger towns were visited, the streets inspected, photographs taken and data concerning the improvement of the streets obtained. Several municipalities to which a visit was not paid furnished tabulated statistics by mail.

Proctor Boulevard, Hamilton, Ont.

Cited by the report as an excellent example of artistic treatment of city street.

The report covers the following cities and towns:—

Cities.—Toronto, Ottawa, Hamilton, London, Brantford, Fort William, Windsor, Peterborough, Kingston, Kitchener, Port Arthur, Guelph, St. Catharines, St. Thomas, Stratford, Chatham, Belleville, Sault Ste. Marie, Niagara Falls, Sarnia, Galt and Woodstock.

Towns.—Brockville, Oshawa, Welland, Lindsay, Cornwall, Walkerville, Ingersoll, Picton, Dunnville, Aylmer and Seaforth.

In the twenty-two cities and eleven towns covered by the report are 2,291 miles of streets, of which 628 miles, or 27.41 per cent., are paved. The paving covers a total area of 10,200,600 square yards, and the average cost has been approximately $2 per square yard; thus representing an investment of over $20,000,000. Sidewalks in nineteen cities and ten towns have a total length of 2,498 miles and were laid at an average cost of 14¼ cents per square foot. The total investment in sidewalks thus represents an investment of over $6,000,000.

The data for the report was collected and compiled by R. C. Muir, and edited by G. Cameron Parker, both of the staff of the Ontario Department of Highways.

Following are extracts from the report:—

The Street Plan.

The manner in which streets are laid out is a determining factor in many details of a city's welfare. Natural advantages of a situation, by poor street location, may be lost or even converted into obstacles; while on the other hand, apparent obstacles to development, if wisely considered, may be converted into advantages by a suitably arranged street system.

The favorable situation of a business thoroughfare, the accessibility to the residential section, the opportunity for factory and industrial sites, the convenience of railway and shipping facilities, easy drainage, are intimately bound up with the arrangement of streets, which may tend to the congestion of traffic, or may tend to traffic diffusion. A large economy (or waste) of time and money may, for all future, be dependent upon the initial plan of streets.

The aggregate economy, and the diffusion of traffic, produced by diagonal thoroughfares render them an important key to the traffic situation of the future. The more important cross or connecting streets may then be laid out as a series of rings; the entire system resembling a spider-web rather than the common "gridiron" plan of streets.

There are few cities of importance which to-day, if it were possible, would not make radical changes in the layout of their streets. Many cities, after laboring under a handicap for years, have been compelled to carry out expensive schemes of street-widening, and of opening new thoroughfares, to overcome the defects created by neglected growth. The lesson is obvious. Forethought and intelligent planning applied to the street system during the period of growth are fundamental to favorable urban development.

Proportioning of Streets.

Streets are very commonly sixty-six feet in width in Ontario—a width standardized by the Municipal Act, and commonly adopted for roads of the open country. Occasionally a width of forty feet is found, more especially in eastern Ontario; while in some instances eighty feet, one hundred feet, or greater widths have been laid out.

The proportioning of town streets for roadways, sidewalks, and sodded spaces with lines of trees, has tended to a uniformity created by development rather than intentional design. As a village street, wooden sidewalks were laid close to the property lines, and trees were planted between the walks and the open ditches. When durable construction is undertaken, it is usually desirable to preserve the trees. In consequence, the sidewalks may be kept close to the property lines, or they may be moved outside the lines of trees, and some variety of arrangement becomes possible.

In the design of a town street in the business section, the roadway should usually be paved from sidewalk to sidewalk. With the usual width of streets in Ontario, sixty-six feet, this provides for a roadway forty to forty-

two feet wide, and walks on each side twelve or thirteen feet in width. This is the plan of Yonge Street, Toronto, and is generally followed throughout the province; but a roadway thirty feet wide would be ample for many municipalities.

For residential streets—or any street not in the business section—a design which meets with a great deal of favor consists of a roadway 24 feet wide, bordered on each side by a 6-inch concrete curb. Between the curb and the walk is a strip of sod about 6 feet wide; then the sidewalk 5 feet wide; then the remainder of the allowance (9 ft. 6 ins. on a 66-ft. street) is sodded and in appearance added to the depth of the lawns. When streets have been graded and boulevarded in this way, the usual effect is to cause the owners of private property to remove fences, improve their lawns, plant flowers, and make free use of paint. Many residence streets in towns and cities are only 18 or 20 feet from curb to curb and traffic is not inconvenienced. With a narrow roadway the cost of construction is less, maintenance is less, and the appearance of a street is improved by the sodded boulevards.

Selection of Pavements.

There is no "best" material or pavement uniformly adapted to all conditions. The best pavement or road is one which is best suited to the traffic to which it is subjected; which is best laid; and which is chosen with a view to local conditions. A granite block pavement on concrete foundation is the acme of strength and durability, but is utter extravagance on the side street of a village, where a cheap macadam or gravel would suit every need; the best of pavements can be spoiled by using poor materials and inferior workmanship; and stone-concrete, using material brought in by rail, would rarely be considered good judgment if a gravel-concrete pavement, using good local material, could be laid for half the cost. The best pavement is one which gives satisfactory service at least cost—the cost not being first cost alone, but cost after a term of years.

The general treatment of a street and the type of pavement to be laid on it, should depend on varying requirements and conditions, such as,—

(a) The size and wealth of the town or city.

(b) The amount and class of traffic on the street.

(c) The class of street, whether business, residential, etc.

(d) Local materials available for road construction.

Influence of Size and Wealth.

Large cities have greater scope for choice in the matter of pavements than have smaller cities and towns. Wealth is concentrated in large cities, property values are high, and the cost of a pavement is a minor consideration as compared with service. Also, where the amount of paving is great, it is possible to install extensive plants for laying and maintaining certain kinds of pavements, which are impossible in smaller communities. Thus, the use of granite block pavements on heavy concrete foundations is largely confined to wholesale districts or heavily travelled thoroughfares of large cities—subject to the traffic of heavily loaded drays and trucks, and where a quiet pavement is not imperative. In the same way, the extensive plant required to construct and maintain sheet asphalt confines the use of that material to the larger cities.

Traffic.

The amount and class of traffic on a street is an important factor in the selection of a pavement. While roads and pavements disintegrate to some extent by mere exposure to weather, yet the chief cause of destruction is wear under traffic. Many country roads, particularly the main arteries radiating from important towns and cities, carry much more traffic than some city streets. The number of vehicles passing certain points in large cities is very great; thus a 12-hour census of traffic showed over 3,400 vehicles per hour passing Hyde Park Corner in London, England. At the other extreme, some side streets of cities do not carry a dozen vehicles per day, and these only private carriages or delivery wagons. The main county roads adjacent to Toronto have shown a traffic of from 500 to 800 vehicles in ten hours. A traffic of from 100 to 200 vehicles per day is more common adjacent to the smaller cities. To the latter traffic main streets of most villages and towns in Ontario may safely be adjusted.

The growing use of heavy motor trucks is creating a new situation with respect to traffic. The frequent passing of light vehicles causes surface wear; but heavy vehicles shatter the road foundations, particularly when used in the spring when snow is melting and frost is leaving the ground; or in the autumn when the soil is softened after continuous rain. Heavy motor vehicles or heavy vehicles of any kind create a greater need for deep foundations to distribute the wheel load over a greater area of sub-soil.

Class of Street.

Town and city streets may be divided into several well-defined classes:—

(1) Streets of the business section, on which front stores and offices.

(2) Main thoroughfares carrying traffic in and out of the town or to the railway stations, and on which traffic converges.

(3) Important residential streets, not main thoroughfares.

(4) Residential or "side" streets of secondary importance.

The class of street affects the choice and design of a pavement. In a business section, sidewalks are laid to the street line, and the pavement should ordinarily be laid from walk to walk. A pavement is needed which standing horses cannot tear up, and which can be kept clean and free from dust. On a purely residential street, the roadway may be narrowed, the sidewalks may be narrow, sod and trees and a quiet pavement are desirable. On a main thoroughfare, carrying traffic to a station or leading to the country, a wider roadway is needed, and one resistant to wear. Some pavements, such as those of granite block or paving brick, are noisy, and are objectionable on residential streets. Some, such as bituminous surfaces, or concrete, are more easily kept clean than others, and are therefore suitable for retail business blocks; while a limestone macadam, unless oiled, is essentially dusty.

Local Materials.

Local materials should be used as far as practicable to avoid heavy freight charges, and extra cost of handling from the railway cars. Trap rock is a hard, tough stone for road surfaces, and limestone is soft, susceptible to wear. But it will generally be more economical to use a local limestone, and treat it with oil, rather than to import the more durable trap rock by rail. In this the amount of traffic is a factor, and under conditions of heavy traffic, trap rock may be the cheaper in a term of years. Local deposits of gravel may be used in various

ways, commencing with the gravel roadway for light traffic, and—if the gravel is suitable—for heavier traffic, oiling it, treating it with asphalt or tar, or using it in the construction of a concrete pavement. The type of surface can be adapted in many ways, to the local materials available.

Materials Used in Pavements.

The materials used in roads and pavements are comparatively few. In their many combinations and adaptations lies the art of roadmaking.

Commencing with the preparation of the earth foundation by drainage and grading, other materials more commonly involved are gravel, sand, stone, clay and shale, wood, asphalt and tar; asphaltic petroleum and creosote oils; also a few chemicals of more occasional use. The principal element of cost in roadmaking and paving is labor. The materials employed, in their original state and location, are of comparatively little value. The cost of pavements is principally dependent on the labor market, and skill in using labor.

The types of roadways and pavements more commonly used in Ontario are as follows:—

Village Streets.

Residential or Side Streets.—Earth, gravel, broken stone.

Business Section.—Broken stone, oiled or with bituminous penetration; concrete.

Through or Main Street.—Gravel; broken stone; broken stone, oiled or with bituminous penetration; broken stone with Telford foundation; concrete.

Town Streets.

Residential Streets.—Earth; gravel; broken stone; broken stone, oiled or with bituminous penetration.

Business Section.—Broken stone, on substantial foundation, oiled or with bituminous penetration or bituminous mixed surface; concrete; vitrified brick on concrete foundation; bituminous surface on concrete foundation; wood block on concrete.

Through or Main Streets.—Broken stone, oiled or bituminous penetration, and with or without Telford or rubble foundation; concrete.

City Streets.

Residential Streets.—Gravel; broken stone, with or without bituminous treatment; concrete; sheet asphalt; or other bituminous surface on concrete foundation; wood block on concrete foundation.

Retail Business or Office Section.—Sheet asphalt or other bituminous surface on concrete foundation; wood block on concrete foundation; vitrified brick on concrete foundation; asphalt block on concrete foundation.

Wholesale Business Section.—Sheet asphalt; wood block or granite setts on heavy concrete foundation.

Street Railway Allowances.—Broken stone; wood block; vitrified brick or granite setts on heavy concrete foundations; concrete.

Street Intersections.

A development in street improvement resulting from automobile traffic is the demand for curves of larger radius at the corner of street intersections. Past practice resulted in a corner that was nearly square, or had a curve varying from 4 to 10 feet radius. This means that the vehicle could not turn into an intersecting street until it had passed the corner. The driver of a car must either shift gear and slow down to a suitable speed for the turn, or else he may take the turn with an abruptness that is a menace to other vehicles as well as pedestrians. A further alternative practiced by many drivers is to swing widely at the turns, a practice which carries them to the wrong side of the roadway and risks accident.

Toronto, Ottawa, Windsor, Stratford, Chatham, and other cities in Ontario are widening and rounding many of their street intersections. The increasing radius of the curves enables an automobile to follow a course parallel to the curb and keep on the right side of the roadway, with greater convenience and safety.

Permanent Grades.

Permanent grades for all streets are one of the important needs of all villages, towns and cities in planning for immediate and future development. The fixing of such grades means that the sidewalks when laid will conform to the ultimate elevation of the roadway or vice-versâ; and that foundations of residences or other structures fronting on the street will be carried to a height to suit the elevation of walks and roadways.

The lack of permanent grades is seen in nearly all towns and villages of the province. Sidewalks have been laid to suit the surface of the ground on one side of the street, and the necessities of the other side of the street have not been considered. When the time comes to improve the roadway, it is found that its necessary grade is not the same as either of the walks. The result is a lack of uniformity that is very unsatisfactory in appearance, with increased difficulties of drainage. The entrance to some houses or stores is too high above the walk; others are below the walk, with drainage from the walk turned into them. Actions for damages are threatened by property owners.

Remedy is always more or less expensive, difficult or impossible. Prevention is the only satisfactory means. To this end, an engineer should be employed to prepare a plan of permanent grades to which all future street improvement and construction of houses on the street, should thereafter conform. Fixed grades are one of the important factors in a scheme of town planning, which make for future economy and satisfactory results.

Drainage.

Good drainage is a first principle of roadmaking or street construction. This is particularly true in a climate such as that of Canada, where the action of frost is severe. A clear understanding of drainage and its influence on pavements is essential to a skilful handling of the work.

On country highways, open drains at the side of the road are usual for carrying away surface or storm drainage. In many cases it is desirable to supplement open drains with tile under-drains to carry away sub-soil water, or to "lower the water line." Under-drains have a marked effect in keeping the sub-soil of the road free from water, which is particularly necessary in the spring or other wet periods of the year.

Paving can scarcely be considered apart from sewers. Before laying permanent pavements, the probable sewerage requirements of each town, village or city should be carefully considered. To pave streets, then to tear them up to lay sewers, or other under-ground services, is wasteful and short-sighted in the extreme. The town with a good system of sewers has taken the preliminary step toward modern street improvement. If circumstances are such that sanitary sewers will not be required within the life of the roadway or pavement, a village may

reasonably install a system of under-drains for storm-water only, usually a vitrified tile drain, of suitable capacity, laid at the edge of the roadway on each side of the street.

The following tables give reference data regarding the types of pavements laid in some of the leading Ontario towns and cities, the areas laid in 1915 and up to the end of 1915, costs per square yard, etc. :—

Table Showing Extent of Paving in the Cities and Towns in Ontario.

Name of City or Town.	Class of Paving.	Class of Street.	Year first laid.	Total Mileage laid to end of 1915.	Total Square Yards laid to end of 1915.	Total Mileage laid in 1915.	Total Square Yards laid in 1915.	Total Cost per Square Yard prior to 1915.	Foundation. Thickness and Kind.	Foundation. Cost per Square Yard, 1915	Surface. Thickness including binder.	Surface. Cost per Square Yard, 1915
Fort William**	Asphaltic Concrete	Business and Residential	1914	2.16	57,798	.....	.....	$2.60	6 in. Concrete	.....	3 inches	.....
"	Tar Coated Macadam	Residential	1911	5.26	56,117	0.77	9,730	1.32	8 in. Rubble	$0.56	3½ "	$0.65
"	Asphalt Block	Business	1906	1.67	47,383	.....	.....	3.98	8 in. Concrete	.....	4 "	.....
"	Rocmac	Residential	1911	1.48	24,523	.....	.....	1.55	8 in. Rubble	.....	3 "	.....
"	Sheet Asphalt	Business	1911	0.59	14,613	.....	.....	3.26	8 in. Concrete	.....	3 "	.....
"	Bitulithic	Business	1911	0.24	7,466	.....	.....	3.35	8 in. "	.....	2 inches	.....
"	Tar Filled Macadam	Residential	1913	0.07	724	.....	.....	2.00	.....	.....	3 "	.....
		Total	.....	11.47	208,624	0.77	9,730	.....	.....	.....	.....	.....
Windsor	Concrete	Residential	1907	28.74	346,843	1.35	18,986	1.15	.....	.....	7 inches	1.35
"	Asphalt Block	Business and Residential	1903	3.70	113,187	0.13	2,480	2.70	6 in. Concrete	0.70	4 "	1.79
"	Cedar Block	On heavy grades from Wharf	1906	0.53	8,040	0.03	501	1.90	6 in. "	0.70	5 "	1.65
		Total	.....	32.97	468,070	1.51	21,967	.....	.....	.....	.....	.....
Peterborough	Asphaltic Concrete	Business and Residential	1913	4.21	78,383	1.86	33,920	2.06	5 in. Concrete	0.64	2½ inches	1.30
"	Bitulithic	Business	1914	0.34	2,494	.....	.....	2.24	5 in. "	.....	2½ "	.....
"	Concrete	Residential	1912	0.07	975	.....	.....	0.98	.....	.....	6 "	.....
		Total	.....	4.62	81,852	1.86	33,920	.....	.....	.....	.....	.....
Kingston*	Asphalt Block	Business and Residential	1911	1.53	25,458	.....	.....	2.75	4 in. Concrete	.....	4 inches	.....
"	Bituminous Concrete	Residential	1911	1.25	17,800	0.36	3,740	0.90	5 in. Macadam	.....	3 "	0.72
"	Asphaltic Concrete	Business	1914	0.55	14,200	.....	.....	2.35	4 in. Concrete / 6 in. "	0.60	3 "	.....
		Total	.....	3.33	57,458	0.36	3,740	.....	.....	.....	.....	.....
Kitchener	Tar Filled Macadam	Residential	1910	6.42	85,691	1.70	22,445	1.14 / 1.36	5 in. Macadam / 5 in. Concrete	0.55 / 0.80	3 inches	0.48
"	Bitulithic	Business and Residential	1910	3.02	60,459	.....	.....	2.41	5 in. "	.....	2½ "	.....
"	Wood Block	Business	1914	0.44	10,740	.....	.....	3.10	6 in. "	.....	4 "	.....
"	Concrete	Business	1915	0.20	2,868	0.20	2,868	.....	.....	.....	7 "	1.60
		Total	.....	10.08	159,758	1.90	25,313	.....	.....	.....	.....	.....
Stratford	Tar Filled Macadam	Residential	1909	4.42	53,151	1.45	18,715	$1.35	5 in. Concrete	$0.70	3 inches	$0.47
"	Westrumite	"	1909	3.56	40,634	.....	.....	2.00	5 in. "	.....	2 "	.....
"	Asphalt Block	Business	1906	1.05	30,954	.....	.....	.....	6 in. "	.....	4 "	.....
"	Brick	"	1906	2.12	30,287	.....	.....	2.45	5 in. "	.....	4 "	.....
"	Concrete	Residential	1914	0.50	6,404	.....	.....	1.30	.....	.....	7 "	.....
		Total	.....	11.65	161,430	1.45	18,715	.....	.....	.....	.....	.....
Chatham*	Bitulithic	Business and Residential	1903	5.61	79,708	.....	.....	2.45	5 in. Concrete	.....	2½ inches	.....
"	Brick	Business and Residential	1903	3.68	56,261	.....	.....	2.50	5 in. "	.....	4 "	.....
"	Asphalt Block	Business	1903	2.29	37,142	.....	.....	2.60	5 in. "	.....	4 "	.....
"	Concrete	Residential	1908	2.14	28,185	0.64	8,058	1.20	.....	.....	7 "	1.12
		Total	.....	13.72	201,296	0.64	8,058	.....	.....	.....	.....	.....
Belleville†	Asphaltic Concrete	Business	1914	0.70	17,660	.....	.....	2.38	5 in. Concrete	.....	3 inches	.....
"	Rocmac	Residential	1915	0.39	7,233	0.39	7,233	.....	5 in. Macadam	$0.30	4 "	0.70
"	Tar Filled Macadam	Residential	1915	0.17	2,222	0.17	2,222	.....	5 in. "	0.40	3 "	0.60
		Total	.....	1.26	27,115	0.56	9,455	.....	.....	.....	.....	.....
Sault Ste. Marie‡	Asphaltic Concrete	Business	1913	2.18	38,365	.....	.....	2.27	5 in. Concrete	.....	3 inches	.....
" "	Concrete	Business and Residential	1914	0.70	14,218	0.62	12,845	1.37	.....	.....	7 "	1.37
" "	Bitulithic	Residential	1913	0.54	10,766	0.21	4,970	2.40	5 in. "	0.90	2 "	1.50
" "	Brick	"	1912	0.45	9,748	0.09	1,800	2.89	6 in. "	1.10	4 "	2.08
" "	Asphalt Surface, on concrete base	"	1915	0.04	766	0.04	766	.....	7 in. "	1.37	¼ "	0.22
		Total	.....	3.91	73,863	0.96	20,381	.....	.....	.....	.....	.....

**Cost includes grading. *Kingston. In 1915, 5,000 sq. yds. water bound macadam built, oil treated. *Chatham. 2,212 sq. yds. concrete on lanes in 1915. †23,000 sq. yds. oil bound macadam built in 1915 besides above-mentioned paving. ‡Minimum width of 1915 pavements, 30 ft. between curbs. One concrete pavement received a surface treatment of hot bituminous material and trap rock screenings.

Name of City or Town.	Class of Paving.	Class of Street.	Year first laid.	Total Mileage laid to end of 1915.	Total Square Yards laid to end of 1915.	Total Mileage laid in 1915.	Total Square Yards laid in 1915.	Total Cost per Square Yard prior to 1915.	Foundation. Thickness and Kind.	Foundation. Cost per Square Yard, 1915	Surface. Thickness including binder.	Surface. Cost per Square Yard, 1915
Niagara Falls....	Brick	Business	1904	1.32	24,531	0.18	4,096	.....	6 in. Concrete	$0.83	4 inches	$1.77
" ...	Concrete	Residential	1911	0.53	9,629	0.22	3,109	$1.47	.....	.....	7 "	1.38
" ...	Westrumite	Residential	1909	0.35	6,680	.....	.....	.....	5 in. "	.....	2 "	.....
		Total	.....	2.20	40,840	0.40	7,205	.....	.....	.....	.....	.....
Sarnia*	Asphalt Block	Business and Residential ...	1905	2.75	50,900	.....	.....	2.30	5 in. Concrete	.....	4 inches	.....
"	Brick	Business	1904	0.27	27,080	.....	.....	2.19	6 in. "	.....	4 "	.....
"	Concrete	Main Artery to the city	1913	1.12	10,571	.....	.....	1.09	.....	.....	7 "	.....
"	Wood Block	Business	1909	0.33	7,800	.....	.....	2.47	6 in. "	.....	4 "	.....
		Total	.....	4.47	96,351	.....	.....	.....	.....	.....	.....	.....
Galt	Tar Filled Macadam	Residential	1911	1.24	18,417	.....	.....	2.05	6 in. Macadam	.....	3 inches	.....
"	Bitulithic	Semi-Business ..	1914	0.20	3,780	.....	.....	2.21	8 in. "	.....	2½ "	.....
		Total	.....	1.44	22,197	.....	.....	.....	.....	.....	.....	.....
Woodstock†	Tar Filled Macadam	Residential	1907	0.77	14,200	.....	.....	0.55	3 in. Macadam	.....	3 inches	.....
"	Brick	Business	1903	0.40	11,283	.....	.....	2.00	6 in. "	.....	4 "	.....
		Total	.....	1.77	25,483	.....	.....	.....	.....	.....	.....	.....
Port Arthur	Bitulithic	Residential	1910	1.12	31,367	.....	.....	$2.75	5 in. Concrete	.....	2 inches	.....
"	Sheet Asphalt	Business	1910	1.41	30,956	.....	.....	2.37	5 in. "	.....	3 "	.....
"	Rocmac	Residential	1910	2.44	30,000	.....	.....	1.25	5 in. Macadam	.....	3 "	.....
"	Asphalt Block	Business	1908	1.15	29,542	.....	.....	3.00	5 in. Concrete	.....	4 "	.....
"	Asphaltic Concrete .	Residential	1912	0.60	15,530	.....	.....	2.40	5 in. "	.....	2 "	.....
		Total	.....	6.72	137,395	.....	.....	.....	.....	.....	.....	.....
St. Catharines* .	Bitulithic	Residential	1913	6.06	96,000	0.84	11,800	2.33	5 in. Concrete	.....	2½ inches	$2.29
" ...	Asphaltic Concrete	Semi-Business and Residential	1913	2.84	42,000	.....	.....	2.20	5 in. "	.....	2 "	.....
" ...	Asphalt Block	Semi-Business and Residential	1906	2.37	37,600	.....	.....	2.42	5 in. "	.....	4 "	.....
" ...	Brick	Industrial	1906	1.10	26,410	0.07	892	2.48	5 in. "	.....	4 "	2.35
" ...	Rocmac	Main Arteries to the city	1913	2.20	14,227	0.44	5,220	1.60	5 in. Rubble	.....	3 "	1.25
" ...	Westrumite	Residential	1913	0.34	4,800	.....	.....	2.00	5 in. Concrete	.....	2 "	.....
" ...	Wood Block	Bridge Floor ...	1915	0.27	4,643	0.27	4,643	.....	6½in. "	.....	3 "	3.33
		Total	.....	15.18	225,680	1.62	22,555	.....	.....	.....	.....	.....
St. Thomas.....	Brick	Business	1898	2.75	52,300	.....	.....	1.90	5 in. Macadam	.....	4 inches	.....
"	Westrumite	Residential	1911	1.45	24,640	.....	.....	1.96	5 in. Concrete	.....	2 "	.....
"	Concrete	"	1913	1.00	18,187	0.17	2,600	1.30	.....	.....	7 "	1.35
"	Tar Filled Macadam.	"	1913	0.80	11,880	.....	.....	1.20	5 in. Macadam	.....	3 "	.....
		Total	.....	6.00	107,007	0.17	2,600	.....	.....	.....	.....	.....
Toronto.....	Sheet Asphalt	Business and Residential ...	1888	217.71	3,373,148	16.28	300,876	..... / $2.25 /	5 in. Concrete / 6 in. " / 8 in. "	$0.82 / 0.98 / 1.30	3 inches	$1.20
"	Bitulithic	Residential	1903	49.63	728,949	4.06	67,014	2.70	6 in. "	0.98	2 "	1.60
"	Brick	Business and Residential ...	1893	31.56	580,526	2.06	45,319	3.40	6 in. "	0.98	4 "	2.05
"	Asphaltic Concrete .	Residential	1912	8.40	136,738	0.54	7,856	2.60	6 in. "	0.98	3 "	1.36
"	Asphalt Block	Business	1903	6.28	92,767	.....	.....	3.45	6 in. "	.....	3 "	.....
"	Stone Block	Business	1884	1.56	84,055	.....	.....	.....	.....	.....	.....	.....
"	Rocmac	Residential	1912	4.56	60,162	1.59	19,621	1.90	8 in. Rubble	0.70	3 "	1.00
"	Tar Filled Macadam	Residential	1913	3.09	50,000	.....	.....	.....	.....	.....	3 "	.....
"	Concrete	Residential	1905	6.03	46,000	2.47	22,000	.....	.....	.....	6 "	1.54
"	Cedar Block	Business	1881	2.90	40,000	.....	.....	.....	.....	.....	.....	.....
"	Wood Block	Business	1907	1.05	20,000	0.05	5,543	.....	8 in. Concrete	1.30	4 "	3.30
"	Dolarway	Residential	1913	0.69	8,658	.....	.....	1.65	6 in. "	.....	⅜ "	.....
		Total	.....	333.46	5,221,001	27.05	468,229	.....	.....	.....	.....	.....
Ottawa*	Sheet Asphalt	Business and Residential ...	1895	41.89	790,536	5.71	97,150	2.20 / 2.60	6 in. Concrete / 8 in. "	1.20 / 1.60	2¾ inches	1.10
"	Tar Macadam	Business.....	1902	4.95	86,703	.....	.....	1.35	6 in. Macadam	.....	3 "	.....
"	Tar Filled Macadam	Residential	1913	2.68	43,995	1.03	16,300	1.75	8 in. Telford / 6 in. Concrete	0.80 / 1.10	5 " / 4 "	0.80 / 0.55
"	Wood Block	Business.....	1908	1.21	27,642	.....	.....	3.85	8 in. "	.....	4 "	.....
"	Stone Block	"	1907	0.36	7,083	.....	.....	.....	6 in. "	.....	4 "	.....
"	Bitulithic	"	1905	0.62	6,300	.....	.....	1.40	6 in. Macadam	.....	2 "	.....
"	Rocmac	Residential.....	1914	0.34	5,377	0.22	3,225	1.82	8 in. Telford	0.75	3½ "	1.00
"	Asphaltic Concrete..	Business	1914	0.06	1,130	.....	.....	.....	6 in. Concrete	.....	3 "	.....
		Total	.....	52.11	968,766	6.96	116,675	.....	.....	.....	.....	.....

*Sarnia. No work since 1913. 14,120 sq. yds. concrete on lanes. *St. Catharines. Costs include grading. Concrete in lanes, 1,076 sq. yds. *Ottawa. Track allowance, 1915 work, 17,000 sq. yds. stone, 7,700 sq. yds. wood block.

Name of City or Town.	Class of Paving.	Class of Street.	Year first laid.	Total Mileage laid to end of 1915.	Total Square Yards laid to end of 1915.	Total Mileage laid in 1915.	Total Square Yards laid in 1915.	Total Cost per Square Yard prior to 1915.	Foundation. Thickness and Kind.	Foundation. Cost per Square Yard, 1915	Surface. Thickness including binder.	Surface. Cost per Square Yard, 1915
Picton	Tar Filled Macadam	Business	1910	1.00	25,813			$0.90	4 in. Macadam		3 inches	
"	Rocmac	Residential	1914	0.12	2,600			1.00	4 in. "		3 "	
		Total		1.12	28,413							
Dunnville	Tar Filled Macadam	Business and Residential	1915	0.90	17,523	0.90	17,523		5 in. Concrete	$0.95	2 inches	0.35
Aylmer	Concrete	Business and Residential	1913	1.75	30,914			1.49			7 inches	
"	Brick	Business	1911	0.25	7,463			2.29	5 in. Concrete		4 "	
		Total		2.00	38,377							
Seaforth	Asphalt Block	Business	1906	0.33	9,830			2.55	5 in. Concrete		4 inches	
Brockville	Sheet Asphalt	Business	1912	1.02	21,741			$2.10	5 in. Concrete		3 inches	
"	Tar Filled Macadam	Residential	1913	0.76	14,443	0.70	10,813		6 in. Macadam	$0.61	3 "	$0.60
"	Rocmac	Residential	1914	0.67	11,663				6 in. "		4 "	
"	Granite Block	Business	1913	0.03	860			3.40	6 in. Concrete		6 "	
		Total		2.48	48,707	0.70	10,813					
Oshawa*	Concrete	Business	1913	2.52	26,375	0.51	8,973	0.90			6½ inches	1.00
"	Bitulithic	Residential	1912	0.85	15,203			2.45	5 in. Concrete		3 "	
"	Asphalt Block	Business	1911	0.63	9,533			2.49	5 in. "		4 "	
		Total		4.00	51,111	0.51	8,973					
Welland	Brick	Business and Residential	1912	2.17	48,680			2.55	6 in. Concrete	1.00	4 inches	1.55
"	Wood Block	Residential	1914	0.28	6,098			3.00	5 in. "	1.00	4 "	2.00
		Total		2.45	54,778							
Lindsay	Asphaltic Concrete	Business	1914	2.21	40,740			2.00	5 in. Concrete		2½ inches	
"	Asphalt Block	Semi-Business	1910	0.40	6,950			2.75	5 in. "		4 "	
		Total		2.61	47,690							
Cornwall	Tar Filled Macadam		1912	0.10	1,338			0.60			4 inches	
Walkerville†	Concrete	Business	1908	10.23	106,367	0.12	1,814	1.28			7 inches	1.25
"	Cedar Block	Business	1892	4.73	67,751			1.32	5 in. Concrete		5 "	
"	Asphalt Block	Residential	1904	2.77	39,135	0.23	2,731	2.28	5 in. "		4 "	1.96
"	Bitulithic	Business	1904	0.48	14,230			2.17	5 in. "		2 "	
		Total		18.21	227,483	0.35	4,545					
Ingersoll**	Brick	Business	1915	0.57	13,460	0.57	13,460		5 in. Concrete		4 inches	2.09
"	Concrete	Residential	1915	0.26	4,100	0.26	4,100				7 "	1.50
		Total		0.83	17,560	0.83	17,560					
Hamilton	Sheet Asphalt	Business and Residential	1894	39.42	658,975	6.14	90,108	$1.60	6 in. Concrete	$0.65	3½ inches	$0.93
"	Asphaltic Concrete	Residential	1912	5.64	85,466	0.80	11,397	1.70	6 in. "	0.65	3 "	0.92
"	Wood Block	Business and Residential	1909	2.07	35,730	0.11	2,304	3.15	5 in. "	0.57	4 "	2.30
"	Brick	Business	1905	0.39	4,593	0.05	414	2.80	5 in. "	0.59	4 "	1.85
"	Concrete	Residential	1914	0.24	2,728	0.07	1,064	1.15			6 "	0.83
"	Granite Block	Business	1913	0.11	1,541			4.67	6 in. "		4 "	
		Total		47.87	789,033	7.17	105,287					
London	Asphaltic Concrete	Business and Residential	1902	12.39	196,632	4.30	87,096	2.28	6 in. Concrete	1.00	3 inches	1.33
"	Brick	Business	1904	1.68	26,631	0.17	3,050	2.75	6 in. "	1.00	4 "	1.70
"	Bitulithic	Residential	1902	1.48	24,427			2.25	8 in. Macadam			
"	Concrete	Residential	1912	1.06	14,984	0.35	4,928	1.58			7½ "	1.62
"	Asphalt Block	Business	1903	0.30	5,330			2.65	6 in. Concrete			
		Total		16.91	268,004	4.82	95,074					
Brantford	Bitulithic	Business and Residential	1908	2.98	50,128			2.73	6 in. Concrete		3 inches	
"	Westrumite	Residential	1908	2.02	33,847			1.84	5 in. "		2 "	
"	Concrete	Residential	1910	0.49	8,190			1.30			7 "	
"	†Tar Macadam	Residential	1913	0.60	8,000			0.40	6 in. "		3 "	
"	†Asphaltic Concrete	Residential	1913	0.64	6,512			1.28	6 in. "		3 "	
"	Asphalt Block	Bridge Floor	1912	0.05	870			2.50	5 in. "		4 "	
"	Warrenite	Business	1909	0.05	685			1.78	5 in. "		2 "	
		Total		6.83	108,232							

*There are 14,650 sq. yds. track allowance paved; 3,840 asphalt block, 5,410 brick, 5,400 concrete. †In 1915, 4,050 sq. yds. concrete used for lanes.
**Brick cost includes foundation.

TORONTO SEWERS PRIOR TO 1867.

Following are some of the oldest sewers in Canada, all built prior to Confederation. This list was furnished to *The Canadian Engineer* through the courtesy of R. C. Harris, Commissioner of Works, and W. R. Worthington, Engineer of Sewers, of the city of Toronto. It is a complete list of all of the Toronto sewers laid prior to 1867. Some of these sewers are still in service, in whole or in part, but many of them have been entirely reconstructed owing to the greater carrying capacities needed:

Year built.	Location.
1840	Pearl St., Simcoe St. to east end.
1843	Adelaide St., York St. to Bay St.
1843	York St., Front St. to King St.
1844	John St., King St. to Wellington St.
1844	Peter St., Front St. to Queen St.
1844	Queen St., Peter St. to Spadina Ave.
1844	Wellington St., Church St. to Yonge St.
1844	Wellington St., Peter St. to Simcoe St.
1845	Wellington St., York St. to Simcoe St.
1845	Adelaide St., York St. to Simcoe St.
1845	Bay St., King St. to Adelaide St.
1845	Richmond St., Church St. to Yonge St.
1849	Duke St., Sherbourne St. to George St.
1851	Mutual St., Gerrard St. to Wilton Ave.
1855	Agnes St., Yonge St. to Terauley St.
1855	Albert St., Yonge St. to James St.
1855	Albert St., Elizabeth St. to James St.
1855	Bathurst St., Front St. to Queen St.
1855	Berkeley St., Queen St. to Sydenham St.
1855	Centre Ave., Armory St. to Elm St.
1855	Chestnut St., Queen St. to Elm St.
1855	Duchess St., Ontario St. to 140′ W. Parliament St.
1855	Front St., Don River to Trinity St.
1855	Front St., Peter St. to Spadina Ave.
1855	John St., Front St. to Wellington St.
1855	John St., Queen St. to Stephanie St.
1855	James St., Queen St. to Louisa St.
1855	Osgoode St., Chestnut St. westerly.
1855	Queen St., Jarvis St. to Victoria St.
1855	Richmond St., York St. to Simcoe St.
1855	Simcoe St., 180′ N. of Esplanade to Caer Howell.
1855	Sydenham St., Ontario St. to Berkeley St.
1855	Terauley St., Queen St. to Elm St.
1855	Victoria St., Adelaide St. to Gould St.
1856	Shuter St., Yonge St. to Bond St.
1856	Victoria St., Gerrard St. to Gould St.
1856	Carlton St., Church St. westerly.
1856	Centre Ave., Chestnut Place to Elm St.
1856	Duke St., Parliament St. to Berkeley St.
1856	Queen St., Simcoe St. to John St.
1858	Jarvis St., King St. to north of Shuter St.
1858	Parliament St., Front St. to King St.
1859	Elizabeth St., Agnes St. to College St.
1859	Foster Ave., Elizabeth St. to 145′ east.
1859	George St., King St. to Queen St.
1859	Mutual St., Shuter St. to Wilton Ave.
1861	Gerrard St., Yonge St. to Jarvis St.
1861	Jarvis St., Wilton Ave. to north of Shuter St.
1861	Wilton Ave., Dalhousie St. to Jarvis St.

The cost of the report on the Montreal aqueduct made for the city of Montreal by consulting engineers H. E. Vautelet, J. B. McRae and Arthur St. Laurent was approximately $20,000.

FIELD MARSHAL HAIG'S TRIBUTE TO THE WORK OF THE ENGINEER AT THE FRONT.

Recently there has appeared in various newspaper dispatches eloquent testimony of the work of the engineer at the front, all of them thoroughly deserved. Following these reports it is particularly gratifying to read the statement by Field Marshal Haig, covering operations from December 18th, 1916, to the present offensive. He pays the following tribute to the work of the engineers:—

"The prospect of a more general resumption of open fighting can be regarded with great confidence. The systematic destruction of roads, bridges and railways made unprecedented demands on the Royal Engineers, who were already heavily burdened by the work entailed in the preparations for the spring offensive. Our steady progress in the face of great difficulties is the best testimony to the energy and thoroughness with which those demands were met. The bridging of the Somme at Brie is an example of the nature of the obstacles which we encountered, and the rapidity of their removal. In this instance six gaps had to be bridged across the river, where it is of considerable width and where the current flows swiftly. The work was commenced on the morning of March 18, and by 10 p.m. the infantry bridges were completed; by 5 a.m., March 20, a medium-type bridge for horse transport and cavalry was completed, and by 2 p.m. of the 28th heavy bridges, capable of taking all forms of traffic, had replaced the lighter type.

"Throughout the winter the transport problems were most serious, both in the battle area and behind the lines, and on the rapid solution of these success or failure necessarily largely depended. At the close of last year's campaign the steady growth of our armies and the rapid expansion of our material resources had already taxed the roads and railways to the utmost. With winter conditions deteriorating the roads, the difficulty of maintaining them became almost overwhelming.

"An increase of railway facilities of every type and on a large scale therefore became imperatively and urgently necessary. Great quantities of material and rolling stock were required immediately, while subsequently our wants in that regard were considerably augmented by a large program of new construction in the area of the enemy's withdrawal. The task of obtaining the amount of railway material required and the carrying out of the work of construction at the rate which our plans rendered necessary, besides providing labor and material for the repair of roads, was one of the greatest difficulties. Its successful accomplishment reflects the highest credit on the transportation service, of whose efficiency and energy I cannot speak too highly."

A recent report submitted to the Winnipeg Grain Exchange by United States capitalists outlined a scheme for a through railway route from the United States to Petrograd by way of Canada. The scheme has been considered for some time, and negotiations with the railways and governments which will be involved in the project will be opened in the near future. The plan provides for a standard railway line, connecting United States roads through British Columbia and Alaska with Behring Strait and a line from the Siberian coast to the Trans-Siberian Railway. Large ferries would carry freight and passenger cars across the 56-mile-wide strait. Negotiations have been opened with the Russian Government to improve the Trans-Siberian Railway into a modern road instead of a primitive stretch of track overburdened by war transportations. The United States commission to Russia will take up that phase of the proposed line with the new Russian Government.

TRENCHING MACHINE WORK.*

By William W. Brush,
Deputy Chief Engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York.

IN 1909-1910 the city of New York installed between Valley Stream and Amityville, Long Island (a distance of 83,800 feet) a 72-inch lock-bar 7/16-inch steel pipe as a portion of its Brooklyn conduit system. The contract, which was dated November 6th, 1908, was awarded to the T. A. Gillespie Co., and the total estimated cost for all the work, which included culverts, valve chambers, valves and other appurtenances, was $1,879,390.

That portion of Long Island traversed by the pipe is an almost level sandy plain, there being only a few feet difference in elevation between the small valleys and the low, intervening ridges. The material to be excavated was sand, with some gravel and a light sandy top soil. A right-of-way, in general 200 feet in width, with few cross-roads, gave opportunity for the use of any excavating system.

The contractors used practically every known method in excavating the trench, including hand, horse and scraper, clam-shell buckets, steam shovels and the Austen trenching machine. The trenching machine was used for the greater part of the work. It could be, and was, operated from the shallowest trench section up to a maximum depth of about ten feet, the limiting depth being determined by the resultant width of trench, it being necessary to have a secure track foundation on each side of the trench on which the machine travelled, and by which it was supported. Where the depth of the trench was greater than 10 feet, the contractor removed a portion of the material by other methods and then used the trenching machine.

In a section where the average depth of cut was 8 feet, and the work was performed during a period of one month, data are available on which accurate determination of the cost of excavation by this method can be worked out.

Two machines were regularly employed, working in tandem, one machine removing approximately half the material and the other machine completing the trench. This method was considered to give maximum rate of progress. The contractors were desirous of completing the work as rapidly as possible, and the methods adopted were based, first, on progress, and second, on unit cost.

The two machines used were not owned by the T. A. Gillespie Co., but were rented from the F. C. Austin Drainage Excavator Co. at a yearly rental of $8,500 and $9,300, respectively. This rental was based on the total yardage excavated by either machine being 100,000 cubic yards or less, all over and above 100,000 cubic yards being paid for at the rate of $0.055 cents per cubic yard. The machines were worked in tandem for the greater part of the work, and in many cases for the 24 hours in each day.

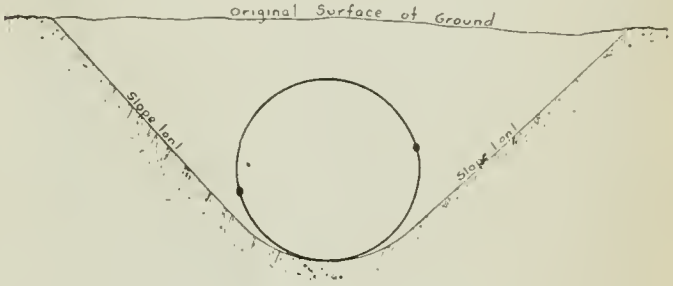
To determine the cost per cubic yard for excavating the trench by use of the trenching machine, a length of trench was taken extending from Sta. 969-52 to Sta. 1090-92, or a total of 12,140 ft. The machines were worked in this section three shifts per 24 hours for one month, from May 15th to June 16th, 1909. An accurate force account was kept by the department for this period.

*Paper read before the American Waterworks Convention, Richmond, Va., May 10th, 1917.

The total cost of excavating per cubic yard was subdivided under the following:—

(1) Rental of machines.
(2) Repairs and coal for machines.
(3) Labor force.

The total amount of excavation made by the two machines was approximately 400,000 cu. yds., or 200,000



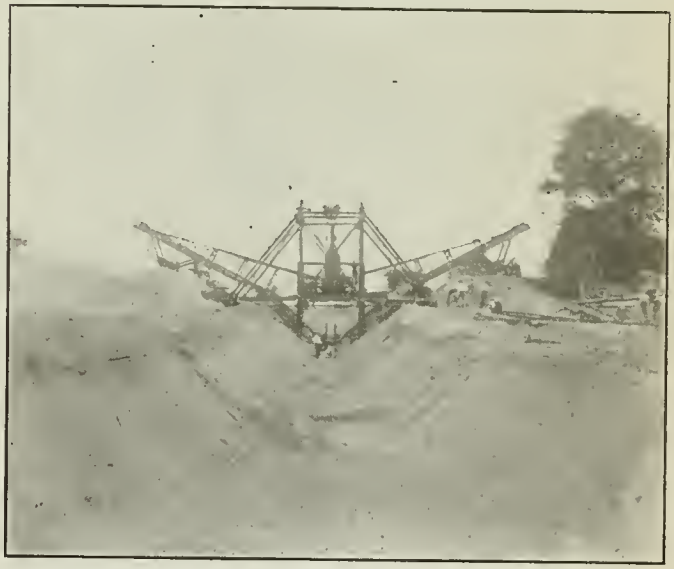
Typical Cross-section of Trench.

cu. yds. for each machine. The cost for rental per cubic yard would, therefore, be for

	Per cu. yd.
Machine No. 1—The first 100,000 cu. yds.....	$.085
" " The second 100,000 cu. yds...	.055
Machine No 2—The first 100,000 cu. yds.	.093
" " The second 100,000 cu. yds...	.055

The average for both machines would be $0.072 per cubic yard.

The trenching machine excavated the trench with side slopes of 1 on 1 and the bottom of the trench rounded to conform with the curve of the pipe. The average depth of the trench for the 12,140 feet excavated was approximately 8.0 feet. This gave a total of 48,560 cubic yards, or 4 cubic yards per linear foot of trench. The repairs on the two machines for the first six months, including the cost of setting up, amounted to $6,000, and the cost of coal for the same period was $2,000. The



Austin Trenching Machine Excavating a 16-ft. Trench.

cost for repairs, coal, etc., for one month would be $1,334, or $0.0275 per cubic yard.

The force included:—

(a) The men who operated the machines.

(b) The gang laying and shifting the track and moving machines.

(c) The gang who trimmed the trench to grade after the machine had passed.

This force was as follows:—

General foreman, two months at $125	$ 250.00
Foreman, 143.5 days at $2.50	358.75
Laborers, 2,308 days at $1.40	3,315.20
Teams, 266 days at $5	1,330.00
Boys, 45 days at 75 cents	33.75
Engineman, 176 days at $4	704.00
Foreman, 171 days at $3	513.00
Skilled laborers, 15 days at $2	30.00
	$6,534.70

This cost of labor shows a cost per lineal foot of trench of $0.5382 and a cost per cubic yard of excavation of $0.1345.

The total cost for excavation would be:—

	Per cu. yd.
Rental of machine	$0.072
Repairs and coal for machine	0.0275
Labor	0.1345
	$0.2340

This cost per cubic yard is equivalent to $0.936 per lineal foot of trench.

The following summary of cost of laying the pipe will enable a comparison to be made between the excavation cost and that of other factors in the work:—

	Per lin. ft.
Clearing and grubbing	$ .037
Excavating	.928
Unloading and distributing	.1911
Laying	.2166
Digging bell holes	.084
Riveting	.345
Caulking	.288
Testing	.24
Backfilling	1.061
Cleaning up, etc.	.0993
	$3.49

It is interesting to note that on this job the backfilling cost 15 per cent. more than the excavation. The usual experience warrants an estimate to backfill at a materially lower cost than the excavation.

Mr. F. H. Whitton, general manager of the Steel Company of Canada and Mr. Wilbur Hutchison, of Winnipeg, have been appointed directors of the Sawyer-Massey Company.

The Imperial Munitions Board has authorized the Algoma Steel Corporation and the Dominion Steel Corporation to roll 50,000 tons of standard section rails for Canadian railroads that helped the Dominion government by allowing rails in service to be exported to the war zone. These roads were unable to secure new rails from United States mills. The Canadian rails will be distributed among the Canadian Pacific, the Intercolonial the Grand Trunk, and the Temiskaming and Northern Railroad Companies.

An increase of 1,000,000 acres to the irrigated area in California could be made by the end of next year, according to a statement recently made by Prof. Frank Adams, of the University of California, if all the irrigation companies of the state can show the same proportionate increase as that indicated by estimates for 1917 filed by 86 companies. Reports of these companies show that in 1917 the increase over 1916 will be from 300,000 to 350,000 acres. There are approximately 450 irrigation companies in the state.

CHEMISTRY IN CANADIAN WOODS.*

By Dr. John S. Bates,
Superintendent of Forest Products Laboratories.

THE destructive distillation of hardwoods is the only important distillation industry in Canada where wood is used as raw material. There are now eleven plants in Ontario and Quebec, and the industry is well organized. It is gratifying to note that manufacture is carried beyond the stage of the crude products, where so many of Canada's industrial activities cease, and that the specially refined and derived products are produced in Canada for local and export trade. In the limited list of chemicals which are regularly exported from Canada there are only three of much importance, namely, calcium carbide, acetate of lime and methyl alcohol, the last two of which are entirely produced by hardwood distillation. It is important to remember that practically all the wood alcohol and acetic acid, which are so essential to modern civilization, are produced by the destructive distillation of hardwood. The Canadian plants together consume over 500 cords of wood per day. Maple, beech and birch are the main species used, although oak, hickory and other hardwoods are suitable if they can be obtained. The primary distillation process is rather crude, the cordwood sticks being run into retorts on cars and the retorts being heated externally by fire which is controlled to some extent. The crude decomposition products which are driven off go through a series of refining operations for the separation and purification of the valuable products.

Hardwood charcoal is the other valuable product, and is mainly used as household fuel and for manufacture of charcoal iron. The wood gas is of rather low heating value and is burned under the retorts. The hardwood tar is also used as fuel at the plant in most cases as the constituents have not the inherent value of the more widely-known coal tar; however, the recovery of certain by-products has important possibilities. The various creosote oils which are obtained in the course of separating the wood alcohol and acetic acid from the tar are at present of minor value, but recent investigations by the Forest Products Laboratories of Canada indicate that they are suitable for the flotation of cobalt and other Canadian ores. So-called beechwood creosote is a standard article in the drug trade, and is made by chemical treatment of hardwood creosote oils.

Wood waste of various kinds can be used in place of coal for the generation of producer gas, and this method of utilization is practised in Europe and to some extent in the United States. The increased efficiency of the producer and gas engine over the boiler and steam engine is a well-known advantage in the handling of fuels. In Canada wood waste occurs in such large quantities and is so easily used as fuel directly under steam boilers that there is not so much occasion for installing the more complicated large-scale gas producers. In line with the manufacture of producer gas it is important to mention the destructive distillation of wood waste modified to yield the maximum amount of wood gas. A number of centres in America are now using wood gas for heating and illuminating purposes and as motor fuel.

The steam and solvent process applies to resinous longleaf pine in the Southern States. The selected wood waste is hogged or chipped, steamed to drive off most

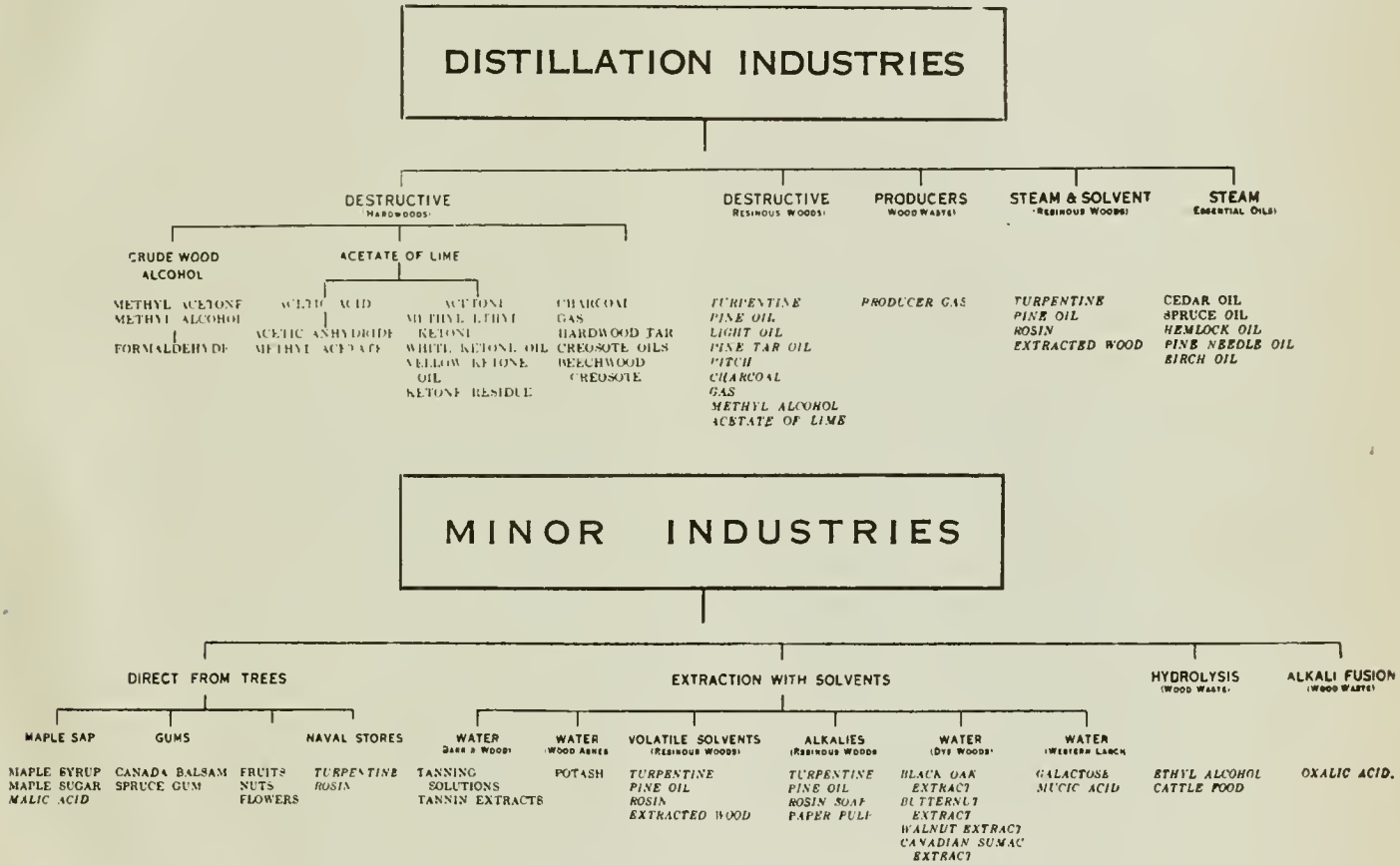
*Abstracted from paper before the Canadian Society of Civil Engineers.

of the turpentine and pine oil and then extracted with gasoline or other volatile solvent for the recovery of rosin. The extracted wood is used in the manufacture of composition flooring blocks, and is also suitable for manufacture of pulp. The resinous wood material in Canada is limited in quantity and not very high in quality, so that economic recovery of products is a more difficult problem.

There is a variety of other processes for recovering products from trees, only a few of which are of importance in Canada at present.

Of products which are taken directly from the living trees maple sap takes quite a large place. The maple sugar industry in Canada furnishes products worth over two million dollars per year, over half of which comes from the province of Quebec. Calcium bi-malate has been recovered from the "sugar sand" in boiling down the syrup, and is considered by the Macdonald College authorities to be superior to cream of tartar or other acid materials used in baking powder. Malic acid can also be produced from the malate of lime, and is a high-priced chemical. Canada balsam and spruce gum are well-known products which are obtained from balsam fir and spruce, respectively. Some of the fruits, nuts and flowers come from forest trees, although it is not intended to include the whole fruit industry, for example, under this head. The naval stores industry of the Southern States provides the bulk of the turpentine and rosin used throughout the world, and involves the "chipping" of long-leaf pine trees. Experiments are now being carried out on western yellow pine in British Columbia with some prospect of commercial success.

Solvents are used in various ways to extract valuable products from certain kinds of wood material. In Canada hemlock bark is used directly in the tanneries and at one plant in New Brunswick for the manufacture of concentrated tannin extract. Oak bark and chestnut wood are of minor importance owing to the limited range of these species in the southern sections of Canada. The recovery of potash from wood ashes was at one time the main source of potash in Canada, but for many years the cheap potash salts from Germany have overshadowed all other sources. Since the outbreak of war there has been some revival of potash recovery in Canada owing to the great advance in prices. Hardwood ashes are the richer for treating, but in any case wood ashes should reach the land as fertilizer. The extraction of resinous woods with volatile solvents and the separation of the turpentine and pine oil from the rosin by distillation is not a promising industry for Canada on account of the limited supply of sufficiently resinous woods as already explained. This also holds true of extraction with weak alkali solutions whereby turpentine and pine oil are distilled with the steam, the rosin recovered from the solution in the form of soap by "salting out" with more alkali and the extracted wood cooked with the strengthened alkali to produce paper pulp. Dye woods are of but little importance in Canada. The extract of black oil is used partly as a tanning material and partly as a dye, while walnut and butternut extracts give a brown coloring material and the flowers of sumac a red dye, which is at least used locally throughout the country. The laboratory of the United States Forest Service has made an interesting discovery that western larch contains from 6 to 8 per cent. of water-soluble material, which is mainly galactose sugar. Various products, including table syrup, ethy alcohol and muric acid, which may be used as a constituent of baking powder can be manufactured therefrom. It may



In the above Diagram the Trees named show the Ramifications of Manufacturing in the Chemical Branches of the Wood Industries.

be that a small industry can be established in Western Canada.

By heating a softwood sawdust at moderately high temperatures with a strong solution of caustic soda or caustic potash a large proportion of the wood is converted into sodium oxalate. The valuable product, oxalic acid, can be recovered by precipitation of the extract with lime and treatment of the calcium oxalate with sulphuric acid. One plant has been established in the United States, but it is doubtful if the industry will assume large proportions on account of cheap production of oxalic acid by other chemical methods, especially in Europe.

CONSTRUCTION METHODS FOR ROGERS PASS TUNNEL.

IN *The Canadian Engineer* for March 1st, 1917, there appeared an abstract of the paper by A. C. Dennis, read before the American Society of Civil Engineers on "Construction Methods for Rogers Pass Tunnel."

The following abstract of the discussion of Mr. Dennis' paper is taken from the March Proceedings of the American Society of Civil Engineers:—

R. H. Keays: This is a very interesting paper, as it explains new methods for obtaining speed in driving long tunnels in rock.

Some years ago it was generally stated that the art of tunnel driving in Europe was much further advanced than in America, as was shown by the great progress in the various tunnels through the Alps as compared with America's much more modest attainments. The proper reply was to argue that the reason American engineers did not specialize in speed was that they had no long tunnels to drive, and when, for financial reasons, they found it necessary to speed up their work they would soon find a way to do so. Certainly, some of their records of late years have been very creditable.

In the writer's opinion, a large part of the credit for the great progress should be given to the improved types of drills developed during the last few years. Where it used to be agreed that the controlling feature of speed was the time taken to drill the heading, it is now considered that tunnel driving is a mucking proposition, and the feature to which most attention should be devoted is the cleaning away of the muck.

In explaining why the pioneer tunnel method was used for the Rogers Pass Tunnel, the author states that the usual "top heading and bench" method was considered too slow and the "bottom heading" method too expensive.

As to the "top heading and bench" method, the writer is of the impression that it has not yet shown its capabilities as to speed, no tunnel driving with modern drills having as yet been attempted where speed was the primary object and where the conditions were so nearly ideal for fast work as in the Rogers Pass Tunnel. The writer has never used the bottom heading method, but has always heard it recommended for its economy. Substantiating this claim, the writer knows of several tunnels where it was used, but they were of such short length that speed was of minor importance.

From a careful reading of the paper, the writer is of the opinion that the author has not demonstrated that the pioneer heading has enough advantages to justify its use as a standard method.

The author gives a list of reasons for using the pioneer heading, showing various advantages which no doubt would expedite work in the main tunnel; but, in the writer's opinion, it would be very little. The paragraphs explaining the location of the portals of the pioneer headings, however, would indicate that, on account of avoiding a lot of soft ground work, the pioneer heading could be driven far in advance of the main heading, but as no heading was driven in the main tunnel, using the pioneer heading to work from, the writer does not understand how greater speed was made in the main tunnel on this account. It merely cheapened the cost of driving the pioneer heading and provided better dumping ground.

The writer assumes that the main heading was being excavated at one face only at any one time, and also that enlargement operations were being carried on at one place only.

Of the reasons given by the author for adopting the pioneer heading, No. 2 is the only one that could tend to expedite work in the main tunnel. Reason No. 1, treating of ventilation, should have no influence on the speed, as the matter of ventilation at the working face can be taken care of very well in the "top heading and bench" method, and ventilation between the heading and portal is not important.

No. 3, of course, would not be an advantage in the "top heading and bench" method, for the enlargement operations would be close to the heading.

No. 4 could hardly be called an advantage, for the rate of speed depends on the enlargement operations.

No. 5 is rather unimportant.

No. 6 would also be of no advantage, as the enlargement operations are close to the heading.

Ventilating systems, as usually put in, are disappointing. There is no agreement as to the relative advantages of the pressure and suction systems, the size of pipe to be used, the pressures, or the quantity of air necessary.

It may be said that much larger pipes are required with suction than with pressure systems in order to handle the same quantity of air. The suction system keeps the air of the whole tunnel in relatively good condition, but, at the heading itself, where the men are working, it has the least effect. This trouble is augmented, generally, by the fact that the pipe used is of very light weight and is leaky at the joints, so that there may be very little air taken in at the end.

The pressure system, on the other hand, clears out the heading first, so that the men can go back to work immediately, and ventilation between the working face and the portal is not important.

The pressures generated at the fan are usually so low that a very large pipe is needed in order to get the volume. For economical reasons, a large pipe is always made of light material, which is not satisfactory.

The writer, therefore, on account of the foregoing considerations, believes that a medium pressure system, using a relatively small, screw-joint, standard steel pipe for delivering air to the heading, is the best.

On a recent job he used a Connersville blower, good for a pressure of 10 lbs., delivering 750 ft. of air per min. to a heading somewhat more than a mile distant. The pipe was of steel, 6 ins. in diameter, and the maximum pressure was about 7 lbs. The condition of the air at the heading was always good. The heading and bench were always shot at the same time, every 8 hours, and the blower was usually run for about 2 hours each time.

F. Lavis: This account of the most successful tunnelling operation in North America—and this is said with, it is believed, due appreciation of all the work of this kind

which has been done in recent years—is a tribute to the advent of the engineer as a director of a type of construction which requires the planning and organizing ability of which usually only the trained engineer is capable.

Confronted with the problems of organization required for the successful economical completion of the long Alpine tunnels, Europeans long ago realized that these were problems for the engineer, and were not of the kind which could be put through solely by "pick, shovel, and pluck," or mere driving power, unaided by a trained mind to plan and execute.

The writer fully recognizes the value of the qualities of the contractor, especially those of the railway contractor, which are very necessary, and which engineers seldom possess. The need of planning, of co-ordinating the work of the organization with the plans, the successful modification of the plans to fit both the conditions and the organization as they develop, are, however, essentially qualifications which the properly trained engineer alone possesses.

Though this is not the first tunnel driven in North America which has demonstrated the ability of the engineer as an organizer along lines which require this necessary co-ordination of planning with execution, it is the latest and most successful, and the writer believes that the realization of this phase, of the conduct of the operations which have resulted so successfully, is of quite as great importance as the recognition of the successful application and improvement in the "pioneer heading" method, important as this latter is as a demonstration of efficiency.

The paper is filled with instances which show the careful, continuous study of conditions and improvements in details as the work progressed. Many of these latter are not altogether new; some of them have been advocated by the writer and others; but as their general application to tunnelling is by no means common, even yet, it seems permissible, even at the risk of repetition, to refer briefly to some of them:

Ventilation is a *sine qua non.*

Bonus system used.

Hammer drills used entirely, columns carefully set with relation to line and grade, holes pointed by clinometer.

Three helpers were used for each two drills.

Fuse was used instead of batteries for blasting.

Water was used to wet down the muck pile and wash the dirt from the sides, roof, and face.

Muckers have brief rest between each carload.

Mucking sheets were used.

There is also one statement full of significance to those who have had much tunnel experience, namely, that "the plant was properly put in and properly looked after, and caused practically no delay." This epitomizes the attitude of those responsible for the conduct of the work, and indicates one of the most important reasons for the success attained.

Lazarus White: The pioneer tunnel was of quite a small bore, and, as Mr. Dennis has stated, it served primarily for ventilation, because through it any quantity of air was sent around the heading, and blew out the smoke. The tunnel was both the driest and the best ventilated of any the speaker has visited. On account of the extensive blasting that was done, it must be realized that the ventilation had to be well nigh perfect, because from fifteen to twenty rounds were set off in succession in order to break up the rock ahead of the steam shovel.

In any ordinary method of tunnel ventilation, this would have made the work difficult, if not impracticable, but, with this pioneer tunnel, the air was sent around and blown through the main tunnel. There was an immense fan in the pioneer heading through which there was always a strong wind blowing.

Another feature, not brought out very strongly in the paper, which contributed very largely to the success of this tunnel, was the drills used. The speaker believes they were little water-fed drills. With these it was possible to maintain the high rate of progress in the heading, and they contributed very largely to the success of the work.

The wooden water pipe, used for ventilation, served its purpose well, and was much superior to the ordinary iron pipe. It was well laid, and the joints were so tight that the exhaust could be conducted through it.

T. Kennard Thomson: The speaker understands that the report of the late Virgil G. Bogue, M.Am.Soc.C.E., is a masterpiece of one of the foremost of old-time railroad engineers, and it would seem that its publication in full, in connection with this paper, would be of great value to other engineers and students. For that reason it is hoped that the author will prevail on the Canadian Pacific Railway Company to allow its publication in full.

One reason for haste in those days was to get some return on the money as soon as possible, and an even more important reason was the fear that, if the road was not quickly completed, a turn of the political wheel might prevent it from being finished for many years.

In addition to the commercial reasons for haste in constructing the Rogers Pass Tunnel, the fear of snow slides may have been another incentive—the author has stated that the snowfall there is from 30 to 50 ft. a year. The speaker assisted in the design of the first snowsheds on this road. These were to be constructed in cuts on the hillsides in such a way that the snow slides or avalanches would never strike directly on the roof of the shed, but merely shoot or slide over it. Some of these designs were modified by others, so that the roofs projected up too far, with disastrous results in every case. Trees adjacent to a snow slide would often be cut off as if by a knife about 20 ft. above the ground, or at the surface of the standing snow, by the force of the wind generated by the falling avalanche. Nothing can be built to stop those giant snow slides after they have fallen from 3,000 to 5,000 ft. The snow and ice piled up in winter many feet, and even after the intense heat of August a depth of some 30 ft. or more would be left.

STEWART COMPANY SUES SUB-CONTRACTOR.

Action to recover $169,619.73 in connection with the Toronto Harbor sub-contract has been entered at Osgoode Hall by the Canadian Stewart Co. against I. A. Hodge, of Syracuse, N.Y. In February, 1914, the Canadian Stewart Company, who are the main contractors on the harbor work, let a sub-contract to Mr. Hodge for part of the ship channel, and the Stewart Company allege that the work was so negligently done that the greater portion of it was rejected by the Minister of Public Works and the material supplied for the work by the Stewart Company was lost. It is further alleged that Mr. Hodge refused to remedy the conditions complained of.

R. S. Lea, consulting engineer, of Montreal, is suing the city of Medicine Hat for commission as consulting engineer on the installation of the city's waterworks, the cost of which was between six and seven thousand dollars. The commission, which was at the rate of 5 per cent. on the cost of installation, has been paid by the city, except a balance of about $6,000, and it is for this amount that the plaintiff has entered suit.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

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BOOK REVIEWS.

The Design of Railway Location. By Clement C. Williams, Professor of Railway Engineering, University of Kansas. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1917. 517 pages, 106 figures, 62 tables, 6 x 9 ins., cloth. Price, $3.50 net. (Reviewed by Wm. C. Willard, plant engineer, Kilbourne & Jacobs Mfg. Co., Columbus, Ohio, formerly assistant professor of railway engineering, McGill University.)

"The Design of Railway Location," by Clement C. Williams, consists of an introductory chapter and four major parts.

Chapter 1, the introduction, devotes 22 pages to a description of early railroads, their types of track and locomotives, operating conditions, and growth of railway systems. Though interesting to read, this chapter could be condensed to one-third the space without in any way reducing its value. For instance, neither the student nor the practical railroad man is materially benefited by a description of how Horatio Allen—"the first man who took hold of a lever to run a locomotive in America"—settled in his own mind whether to take his first trestle at high speed or low speed. In describing the untimely end of the locomotive, the "Best Friend" of Charleston, the author might have completed the story by tracing back "safety first" to the "barrier car"—a car loaded with bales of cotton and placed immediately back of the locomotive—used by the South Carolina Railroad after the explosion of the "Best Friend," and widely advertised as being a great protection to the passengers when the boiler exploded.

Part A takes up the subject of railway economics and legislation. Chapters 2 and 3 discuss capitalization, incorporation, systems of organization, and legal control of railways. Though the divisional and departmental systems of organization are described, no mention is made of the fact that the organization of most American railways are neither clearly divisional nor clearly departmental.

The vast and complex subject of valuation is covered by Chapter 4 in 18 pages.

The approximate methods of estimating the volume of traffic which a new road may expect to receive are thoroughly covered in Chapter 5. This should be supplemented by a statement that the only reliable method of getting a final estimate of the probable volume of traffic is for a traffic expert to make a "house-to-house" field survey of the tributary area.

In Chapter 6 is given a complete list of the 1914 classification of operating expenses as adopted by the Interstate Commerce Commission. Tables are included which give the percentages of the various items of the classification in effect prior to July 1, 1914, for the fiscal year 1914. These would be of greater value if they covered a more extended period. Taxes are briefly referred to in this chapter.

Rates, freight classifications, switching charges, demurrage, c.l. and l.c.l. rates are taken up in Chapter 7, but no mention is made of how little effect the work of the designer of railway location has upon railway rates.

Part B is a discussion of the operating conditions affecting location. It constitutes 179 of the 504 pages and is the most important part of the book. Chapter 8 is a general explanation of locomotive performance. Under "fuel" some mention should be made of pulverized fuel.

Electric traction is discussed in Chapter 9. Because of the growing importance of steam-road electrification no modern book on railway location would be complete without referring to its possibilities.

In Chapter 10 are given weights and dimensions of cars and locomotives, the economy of large cars and locomotives is emphasized, and draft gear and the air brake are described.

Chapters 11 and 12 contain a comprehensive discussion of train resistance, locomotive rating, economic speed of trains, and the location of terminals and sidings.

In Chapters 13, 14 and 15 are discussed grade resistance, ruling grades, value of grade reduction, momentum and minor grades, the velocity or virtual profile, velocity-distance and velocity-time curves, rise-and-fall and its effect upon operating expenses, and pusher grades.

Chapter 16 is a discussion of the effect of distance upon operating expenses. Chapter 17 deals with curvature, its limiting effect upon tonnage and speed, its effect upon operating expenses, and its compensation. Twenty-one pages are devoted to curvature while but 12 pages are allowed for distance.

Part C, consisting of 73 pages, deals with special problems in railway location. Line changes and grade reduction are taken up in Chapter 18; the elimination of grade crossings is discussed in Chapter 19, and the maximum capacity of single track and the necessity for additional tracks are covered in a satisfactory manner in Chapter 20. These three chapters cover matters not heretofore included in books of this nature and are a valuable addition.

Chapter 21 discusses briefly the location of electric interurban railways. The problems arising in the location of electric railways are quite different from those of steam-railway location, and might well be left for a book dealing entirely with electric railways.

The heading of Part D is "Practical Location Surveys." It consists of 105 pages. Chapters 22 to 26 inclusive discuss in order, reconnaissance, the preliminary survey, the location survey, construction surveys, and railroad construction estimates. All of these subjects are covered in a much more thorough manner in books previously published.

Appendix A is a reproduction of the specifications for the formation of the roadway, from the Manual of the American Railway Engineering Association.

In general, the book attempts to cover too broad a field. The topic headings are not numbered and cross-referencing is made cumbersome. The table of contents gives an outline of the data included in each chapter in the place of a complete list of the topic headings.

The Theory and Practice of Working Plans (Forest Organization). By A. B. Recknagel, A.B., M.F., Professor of Forestry, Cornell University. Published by John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. Second edition, 1917. 265 pages, 6 plates, 5¾ x 9 ins., cloth. Price, $2.00 net. (Reviewed by B. E. Fernow, University of Toronto, Toronto.)

The subject matter of this volume can have only a limited interest to the general engineer, except as it is useful to study and understand the organization of any business—in this case the business of furnishing the engineer systematically and continually with one of the important materials of construction—a business which as yet is undeveloped in Canada and hardly on the continent, the business of forestry. It comprises the mathematical side of forest organization.

This organization is based on the realization that the forest crop requires many years, 75 to 100 and more, to mature, that the annual growth cannot be directly utilized, and hence needs special arrangements to permit an annual harvest of appropriate amount, based upon the annual increment—to secure what is technically called the "sustained yield." The problem is to change a naturally intermittent business into an annual one.

The forester is fortunate in having formulated an ideal forest, which would fulfil the requirement of the sustained yield, *i.e.*, the yield which will eventually allow an annual or periodic harvest of the increment. This ideal, the so-called "normal forest," is composed of as many stands differing in age as there are years in the rotation—normal age classes—which represent the normal stock on which the normal increment accumulates, and permits an annual cut of mature timber representing the annual forest increment on the whole property.

The art of the organizer and the object of the working plan is to gradually bring the usually abnormal forest into approximately normal conditions in such a manner that the future is provided for without too much sacrifice of present interests.

This is done largely by determining a proper felling budget during the time of the change to normal conditions, and it may take 100 and more years before the object is attained.

There are eighteen different methods described for approaching this problem, mostly developed in Germany, for regulating the cut and securing systematic procedure.

The first chapter is concerned with the method of securing the basis or data for this regulating, which consist of a forest survey, including ascertainment of forest conditions, stock on hand, increment, actual and normal, yield tables, subdivision of the property, the determination of the rotation, *i.e.*, the felling age or desirable age of harvest, the desirable silvicultural methods, etc.

Some 80 pages are devoted to description of the practices in regard to working plans in Germany and France, Austria, and in America. While in the European countries working plans are really followed, in America, *i.e.*, the United States, the making of working plans is still largely academic discussion. In Canada there is as yet nothing but exploitation of the natural forest without reference to the future and the normal forest; the organization of a continuous business of forest cropping is still only a wish, with little show of realization.

Railway Estimates, Design, Quantities and Costs. By F. Lavis, M.Can.Soc.C.E. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1917. 608 pages, 99 illustrations, 6 x 9 ins., cloth. Price, $5. (Reviewed by G. J. L. Boyd, Creosoted Block Paving Co., C.P.R. Building, Toronto.)

The author has in this book made available in convenient and concise form a vast store of practical information and cost data for engineers called upon to report on the value of, or estimate the probable cost of proposed railways, either before or after surveys have been made,—to estimate the value of existing lines,—to design the general features of a proposed railway or modify the design of an existing line,—to determine the value or utility of such feature of the general design of railways as affect their cost or value as transportation machines.

The work has been prepared by an engineer from his own experience in actual work as well as having had access to the records of many railroads, thus giving an added value to the data.

Under appropriate headings are first given general data, such as preliminary estimates previous to survey, and estimates based on surveys; general costs of complete railroads, etc.; then follows construction methods and costs, including clearing and grubbing, earth and rock excavation, tunnels, masonry, bridges (railway and highway), track and track work, fencing, crossings, section houses, telegraph, signals, shop and yard buildings, stations, etc. Chapter 11 devotes 72 pages to rolling stock, in all its phases, followed by Appendix "A" "General Specifications and Forms of Contract"; Appendix "B," "Appraisal of the Lehigh Valley Railroad"; Appendix "C," "Processes of Timber Preservation"; Appendix "C," "Processes of Timber Preservation"; Appendix "D," "General Railway Statistics," with 31 pages of tables complete an excellent and practical work which should have a place in every consulting and practising engineer's library.

Examples in Battery Engineering. By Prof. F. E. Austin. Published by the author, 1917. 90 pages, 39 illustrations, 4¾ x 7¾ ins., cloth. Price, $1.25. (Reviewed by E. G. Ernest, general manager, Canadian National Carbon Co., Limited, Toronto.)

This book appears to be concise, accurate and to the point, and covers in a comprehensive way the fundamental principles involved in battery engineering. It should be valuable to engineering students and others who use batteries and to those who sell batteries, in order that they may have the knowledge necessary to give the best possible service.

PUBLICATIONS RECEIVED.

Ontario Bureau of Mines.—Twenty-fifth (1916) annual report.

Provincial Board of Health of Ontario.—Thirty-fourth annual report for the year 1915.

Canadian Society of Civil Engineers.—Transactions of the society from January to June, 1916.

The Kingshighway.—A report by the City Plan Commission, St. Louis, Mo., January 23, 1917.

Annual Report of The J. G. White Companies, general offices, 43 Exchange Place, New York City.

Manitoba Public Utilities Commission.—Fifth annual report for the year ended November 30th, 1916.

Sun Oils, Vol. VI., Filling and Shipping.—Published by the Sun Co., 1428 South Penn Square, Philadelphia, Pa.

Mineral Production of Canada.—Annual report for the calendar year 1915. Issued by the Department of Mines, Ottawa.

Sewage Disposal.—Twelfth and thirteenth semi-annual reports, 1916, of the Sewage Disposal Commission of the city of Fitchburg, Mass.

Wheaton District, Southern Yukon.—By D. D. Cairnes. Supplement to Memoir 31, Geological Survey, Department of Mines, Canada.

The Southern Plains of Alberta.—By D. B. Dowling. Memoir 93, No. 78 Geological Series, Geological Survey, Department of Mines, Canada.

Association of Dominion Land Surveyors.—Report of the tenth annual meeting held at Ottawa on January 31st and February 1st and 2nd, 1917.

Tennis Every Day on Concrete Courts.—Illustrated pamphlet, published by the Portland Cement Association, 111 West Washington Street, Chicago, Ill.

The Remodelling of an Old Graving Dock at Southampton.—By R. N. Sinclair, M.C.I. Paper read before the Concrete Institute on February 22nd, 1917.

Asphyxiation from Blast-Furnace Gas.—Technical Paper 106, Bureau of Mines, Department of the Interior, Washington, D.C. By Frederick H. Willcox.

The Coal-Fields and Coal Industry of Eastern Canada. A gereral survey and description by Francis W. Gray. Bulletin No. 14 published by the Dept. of Mines, Canada.

California Railroad Commission.—Bulletin of the progress of the California Railroad Commission's investigation of railroad grade crossings in the State, April, 1917.

Forest Branch.—Report of the Forest Branch, Department of Lands, British Columbia, for the year ending December 31st, 1916. M. A. Grainger, chief forester.

Scroggie, Barker, Thistle and Kirkman Creeks, Yukon Territory.—By D. D. Cairnes. Memoir 97, Geological Series No. 79. Issued by the Dept. of Mines, Ottawa.

Recent and Fossil Ripple-Mark.—By E. M. Kindle. Canada Geological Survey Museum Bulletin No. 25, Geological Series No. 34. Issued by the Department of Mines, Ottawa.

Canadian Society of Civil Engineers.—Report of proceedings of the thirty-first annual meeting held at the society's house, 176 Mansfield Street, Montreal, January 23rd and 24th, 1917.

Chemical and Biological Survey of the Waters of Illinois.—Report for year ending December 31st, 1915, Water Survey Series No. 13. Published by the University of Illinois, Urbana, Ill.

How to Build Up Furnace Efficiency.—A handbook of fuel economy. By Jos. W. Hays, Rogers Park, Chicago, Ill. Tenth edition, 1916. 154 pages, 5 x 7¼ ins., paper cover, illustrated. Price, $1.00.

Oxygen Mine Rescue Apparatus and Physiological Effects on Users.—By Yandell Henderson and James W. Paul. Technical Paper 82, Bureau of Mines, Department of the Interior, Washington, D.C.

Building and Ornamental Stones of Canada.—Report covering the provinces of Manitoba, Saskatchewan and Alberta, by Wm. A. Parkes, B.A., Ph.D. Published by the Department of Mines, Ottawa.

The International Nickel Company.—Fifteenth annual report of the International Nickel Co., 43 Exchange Place, New York City, for the fiscal year ended March 31st, 1917. President, Ambrose Monell.

The Alloys of Chromium, Copper and Nickel.—A preliminary study by D. F. McFarland and Oscar E. Harder. Bulletin No. 93, Engineering Experiment Station, University of Illinois, Urbana, Ill. Price 30 cents.

Report on Enlargement of the Montreal Aqueduct.—By H. E. Vautelet, Arthur St. Laurent and J. B. McRae, consulting engineers. Reprinted from *The Canadian Engineer*, issues of May 31st and June 7th, 1917.

Bulletin of the Imperial Institute.—A quarterly record of progress in tropical industries, etc., of the natural resources of the colonies and India. Published by John Murray, Albemarle Street, London, W., England.

Magnetic and Other Properties of Iron-Aluminum Alloys Melted in Vacuo.—By Trygve D. Yensen and Walter A. Gatward. Bulletin No. 95, Engineering Experiment Station, University of Illinois, Urbana, Ill.

Public Road Mileage and Revenues.—Bulletin No. 389 of the United States Department of Agriculture, Washington, D.C., dealing with public road mileage and revenues in the Central, Mountain and Pacific States, 1914.

Combustion in the Fuel Bed of Hand-Fired Furnaces.—By Henry Kreisinger, F. K. Ovitz and C. E. Augustine. Technical paper No. 137. Issued by the Bureau of Mines, Department of the Interior, Washington, D.C.

The Rational Design of Reinforced Concrete Wharves and Jetties, with particular reference to those for wet docks that have a permanent water level. Paper read before the Concrete Institute by W. Cleaver, M.Inst.C.E., on March 22nd, 1917.

The Results of Physical Tests of Road-building Rock in 1916, Including all Compression Tests.—By Prévost Hubbard, chemical engineer, and Frank H. Jackson, Jr., assistant testing engineer. Bulletin No. 537 issued by the United States Dept. of Agriculture, Washington, D.C.

Water Hammer Problems Solved by the Use of Alignment Charts.—Water hammer phenomena reviewed with charts for graphical solution of Joukovsky's and Allievi's formulæ. By R. L. Hearn, B.A.Sc., hydraulic department, Hydro-Electric Power Commission of Ontario. Reprinted from *The Canadian Engineer*, December 7th, 1916.

The Philadelphia Plan for Unified Federal Regulation of Railroads.—Presented by the Philadelphia Bourse and a program of basic regulatory legislation presented by the Philadelphia Joint Committee on the Reasonable Regulation of Railroads. Secretary, Emil P. Albrecht, 58 The Bourse, Philadelphia, Pa.

Engineering.—A brief prepared for the Governor and the General Assembly of the State of Illinois concerning the work of the College of Engineering and the Engineering Experiment Station of the University of Illinois, Urbana, Ill., and a statement of their needs for the two years beginning July 1, 1917. Compiled by the Dean and heads of departments.

International Joint Commission.—Hearings of the International Joint Commission in re remedies for the Pollution of boundary waters between the United States and Canada, being public hearings held at Buffalo, N.Y., and Detroit, Mich., June 21-27, 1916, and Ogdensburg, N.Y., August 25, 1916. Published by the United States Government, Washington, D.C.

Design of Outlet Sewers and Sewer Outlets.—Report submitted to the Board of Estimate and Apportionment, City of New York, by the chief engineer of the board on behalf of the consulting engineers, recommending the adoption of certain general rules governing the design of outlet sewers and sewer outlets, which report was approved and which rules were adopted by the Board of Estimate and Apportionment at a meeting held on February 23, 1917.

United States Government Specification for Portland Cement.—Circular No. 33 of the Bureau of Standards, Department of Commerce, Washington, D.C. S. W. Stratton, director. This specification is the result of several years' work of a joint conference, representing the United States Government, the American Society of Civil Engineers, and the American Society for Testing Materials. It was adopted by the United States Government and by the American Society for Testing Materials, to become effective January 1st, 1917.

The Activated Sludge Process of Sewage Treatment.—By J. Edward Porter, chemical engineer, General Filtration Co., Inc., Rochester, N.Y. A bibliography of the subject arranged in chronological order. It includes, in addition, the nomenclature concerning the activated sludge process as suggested by Messrs. Dallyn, Hammond and Hatton, a committee appointed for that purpose by the American Society of Civil Engineers, notes on patents, etc. This publication will undoubtedly be found very useful and informative to all who are interested in sewage disposal and should find a place in the library of all civil engineers. Contains forty-two pages, 6 x 9 ins.

CATALOGUES RECEIVED.

The Whalen Form.—A 24-page illustrated booklet issued by E. J. Whalen, Syracuse, N.Y.

Excelsior Airometer.—A 15-page illustrated leaflet issued by The Denver Hydro Co., Denver, Colorado.

How a Tarvia Macadam Roadway is Constructed.—A 36-page illustrated booklet published by The Barrett Co., New York.

Portable Rock-drilling Outfits.—Catalogue No. 15, illustrated, issued by Chris D. Schramm & Son, Philadelphia, Pa.

Birch Pump Valves.—Illustrated folder issued by the Birch-Hintz Manufacturing Co., Chicago, giving descriptions of installations of their pump valves.

Thermodynamic Analysis of duty test of the De Laval steam turbine-driven centrifugal pump at Montreal.—Thirty-one page illustrated booklet issued by the De Laval Steam Turbine Co., Trenton, N.J.

Modern Methods of Brick Pavement Construction for roads and streets built with wire cut-lug brick. A 27-page illustrated booklet, published by The Dunn Wire-Cut Lug Brick Co., Conneaut, Ohio.

Storage Buildings.—Booklet issued by Lockwood, Greene & Co., engineers, 60 Federal Street, Boston, illustrating and describing a number of storage and warehouse buildings recently designed by them.

Tarvia, Tarvia-X and Tarvia-B.—Three booklets issued by The Barrett Co., New York, describing the use of Tarvia, and giving illustrations of roads in different parts of the United States on which it has been used.

Wood Tanks and Vats.—Folder issued by the Goold, Shapley & Muir Co., Limited, Brantford, Ont., describing with illustrations wood tanks and vats for all purposes, and towers and tanks for sprinkler, water supply systems, etc.

Standard Cast-iron Extension Shut-off Boxes for water and gas service pipes and street mains.—Illustrated booklet published by Bingham & Taylor, Buffalo, N.Y. Contains 28 pages and describes their different types of boxes, etc., together with price lists.

Mineral Rubber Pipe Coating.—Illustrated, 23-page booklet issued by the Standard Asphalt & Rubber Co., 208 South La Salle Street, Chicago, Ill., describing Sarco mineral rubber pipe coating for protecting steel, cast or wrought iron pipe against corrosion, tuberculation, electrolysis, earth's salts, or other damaging influences.

Chanelath Hand Book.—Sixty-four pages and cover, 6″ x 9″, coated paper, well illustrated. Containing information descriptive of Chanelath, and data on its erection, design, specifications, etc. Illustrates use for floors, ceilings, partitions, curtain walls, etc. Distributed by the Burns Cement-Gun Construction Co., Toronto, agents for the Northwestern Expanded Metal Co., Chicago.

Steel Storage Tanks and Plate Metal Work.—A 24-page and cover booklet issued by the Canadian Chicago Bridge & Iron Co., Limited, of Bridgeburg, Ont. Contains a score of illustrations of Canadian work carried out by this company, including overhead tanks for the city of Toronto filtration plant; for all of the Canadian railroads; for Canada Car Co., Proctor & Gamble, City Dairy Co. and many other industrial concerns; and for municipal waterworks at Stratford, Cartierville and a dozen other Canadian municipalities.

Progress in Waterworks Pumps.—A 48-page booklet published by the De Laval Steam Turbine Co., Trenton, N.J., discussing the general economic and engineering conditions affecting the design and installation of steam turbine-driven centrifugal pumps for city water supply. Installations in fifteen of the principal cities of the United States and Canada are described, including 34 units aggregating 999,000,000 gallons per day capacity. The publication should be of value to anyone interested in the handling of water in large quantities.

Air Compressors.—Bulletin K-302, 16 pages, 6 x 9 ins., illustrating a line of steam-driven, straight-line, single-stage air compressors manufactured by the Canadian Ingersoll-Rand Co., Limited, of Montreal. The type of machine described is designed to cover the field of those requiring compact, self-contained units of small and medium size for service in shop, foundry, mill or electrical plant, etc. Automatic splash lubrication, dust-proof construction, "Circo" silent leaf valves and quick convertibility to belt-drive are among the leading features of the design dwelt upon in this publication.

THE WILEY BULLETIN.

An innovation that will be welcomed by all technical men is "The Wiley Bulletin," the first number of which has appeared under date of May, 1917. This bulletin is a booklet devoted to the publications of John Wiley & Sons, Inc., of New York, and is being distributed in Canada by their agents, the Renouf Publishing Co. of Montreal.

It is divided into thirteen departments: namely, civil engineering; mechanical engineering; electrical engineering; mathematics; chemistry; medicine and sanitation; mining, metallurgy and geology; agricultural engineering; agriculture and horticulture; forestry; drafting and design; valuation and management; and military.

Under each heading is given a list of the latest, recent and forthcoming books. Photographs and biographies of some of the authors are published, together with a brief review of each book and its table of contents. The bulletin will be most useful to engineers in enabling them to keep up-to-date in their technical reading and in deciding what books to buy.

Among the forthcoming books which are indexed in the bulletin are the following:—

Rural Highway Engineering, by Geo. R. Chatburn, C.E., Prof. of Applied Mechanics, University of Nebraska.

Water Supply Engineering, by A. Prescott Folwell, author of "Municipal Engineering Practice" and "Sewerage." This is the third edition of this book, revised and enlarged.

Steam Charts, by F. O. Ellenwood, Prof. of Heating and Power Engineering at Cornell University. This special edition has been published in compliance with the suggestion of engineers engaged in steam turbine design. New tables have been added.

Hydro Electric Stations, by David B. Rushmore and Eric A. Lof. This book will cover both the hydraulic and electrical equipment, but with emphasis on the latter, it being intended primarily for electrical engineers.

Atmospheric Circulation and Radiation, by Frank H. Bigelow, Prof. of Meteorology in the Argentine Meteorological office.

Bio-Chemical Catalysers, by Dr. Jean Effront, Director of the Institute of Fermentations of Brussels. (English translation by Prof. Samuel C. Prescott, Massachusetts Institute of Technology). A companion volume to the authors' "Enzymes and Their Applications."

Quantitative Analysis, by Prof. Henry Fay, of the Massachusetts Institute of Technology.

The Chemistry of Colloids, by Richard Zsigmondy. (Authorized translation by Prof. E. B. Spear, Massachusetts Institute of Technology). This includes a description on industrial colloidal chemistry and on clays and colloids in sanitation.

Biochemical Catalysts in Life and in Industry, by Dr. Jean Effront. (Translation by Prof. Samuel C. Prescott, Massachusetts Institute of Technology).

Testing for the Flotation Process, by A. W. Fahrenwald, Prof. of Mining and Metallurgical Engineering, New Mexico State School of Mines.

Technical Analysis of Brass, by Wm. B. Price, Chief Chemist, Scoville Mfg. Co., Waterbury, Conn. Second edition, thoroughly revised.

Electric Furnaces in the Iron and Steel Industry, by W. Rodenhauser and I. Schoenawa. Second English editon, by C. H. Vom Baur. Revised to bring the book abreast of modern practice.

Ordnance and Gunnery, by Lt.-Col. Wm. H. Tshappat, Prof. of Ordnance and Gunnery at the N.S. Military Academy. This book will be used at West Point as a textbook, replacing Lissak's Ordnance and Gunnery.

A company, registered in New Zealand, with a capital of £180,000 in £1 shares, £80,000 of which is required almost immediately, has undertaken a very important and interesting mining proposition at Yetholme, near Bathurst, in New South Wales. There is there a huge field of low-grade molybdenum ore, and the company has acquired three properties carrying this ore, which have been amalgamated in one under the name of the Mammoth Molybdenite Mines. They comprise an area of 327 acres. A start will be made with a ball mill, treating 40 tons of ore per day. Later, it is intended to treat 1,000 tons per day, yielding £42,000 per week, and employing a large number of men. Even at that rate, the mine is estimated to have forty years of life.

A GOOD ROADS COMPETITION.

"The province of Saskatchewan seems a pretty remote place to many people in the United States," says a recent bulletin of the American Highway Association, "and there is a general feeling that it is decidedly 'new,' and not quite ready to take on all the obligations regarding public works which are assumed in sections settled for a longer period. Yet there are many parts of the United States where the improvement of the roads receives much less intelligent attention than is paid to it in this Canadian province. Perhaps one reason for the good results attained there has been the readiness of the authorities to profit by experience elsewhere. The amount of money they have had to spend on roads has been small. The Good Roads Year Book gives last year's expenditure as only $450,000, although this is unusually low on account of war conditions. But this money is made to yield the maximum return by intelligent outlay. Over 2,300 miles of road are now being kept in good condition by dragging them by the methods developed by the United States Office of Public Roads. After a country road has been graded and drained, dragging is the best method of keeping it in condition in most cases, and so the Provincial Highway Commission gives numerous prizes every year for the best-dragged roads in each section of the province and a grand prize for the best results of dragging on any road anywhere under its jurisdiction. As a result of this stimulating influence, and the wide distribution of the report giving the results of this annual competition for distinction in public efficiency, the earth roads of Saskatchewan are kept in a condition which would startle the local road authorities in many of the older-settled sections of the United States, could they see them. Moreover, these results are attained at an average annual expense of about $15 to $18 per mile, a sum considerably less than is wasted annually on thousands of miles of earth roads in the original thirteen States without yielding any visible improvement."

DOMINION STEEL CORPORATION.

"We are booked up in steel products to the end of the calendar year," President Workman told the shareholders of Dominion Steel Corporation at the annual meeting held at Montreal last week, "and in addition to that our shell steel output for the first six months of 1918 has been disposed of."

In a general review of the present position and the after-the-war outlook Mr. Workman had this to say:—

"While the statements now before you indicate a greatly improved condition as compared with the previous history of the corporation, it must not be forgotten that lean years have been the rule rather than the exception, and it must, therefore, be my policy to exercise conservatism in all our undertakings. I feel particularly committed to this course, having in view the keen competition that will undoubtedly arise after the war.

"Many corporations engaged in the steel industry across the border have been able, partly through exemption until a comparatively recent date from taxation, and partly by reason of other advantages resulting from the attitude of neutrality long maintained by their government, to accumulate large surpluses, and to practically amortize their plants. We, in Canada, have borne responsibilities of this nature for a much greater period, and it must not be lost sight of that this condition demands careful study and the exercise of rigid economy, in order that we may not be placed in a position of disadvantage as regards our competitors."

The exports of railway material from England for the first three months of the present year were as follows, the corresponding figures for 1916 being added in brackets: Locomotives, £406,203 (£330,487); steel rails, £105,330 (£98,519); carriages, £66,494 (£124,320); wagons, £130,119 (£138,135); wheels and axles, £35,231 (£52,857); tires and axles, £51,242 (£83,348); chairs and metal sleepers, £23,733 (£27,322); miscellaneous permanent way, £117,804 (£105,730); permanent way of every description, £338,580 (£245,488). The tonnage of rails was 12,870 (10,422), and of chairs and sleepers 1,684 (2,666).

Editorial

1867 1917

The Jubilee of Confederation

NEXT Sunday, July 1st, Canada will celebrate the Jubilee of Confederation—the completion of the first half century of the Dominion's life. "The date," says the parliamentary committee appointed to report upon arrangements for the anniversary, "finds Canada with a record of achievements and resources such as few young countries possess, and it finds her also throwing herself into the world's struggle for liberty in a way that sets the final seal of nationhood upon her brow."

While not essentially an engineering topic, it is only fitting that all Canadian papers should make special reference to this notable date, and at this time pass in brief review some of the more remarkable of the country's achievements and resources.

In 1867 Canada comprised four provinces, embracing a narrow strip along the lower lakes and the St. Lawrence, with a limited frontage on the Atlantic. In 1917 there are nine provinces (besides a large unorganized territory) embracing half a continent, stretching from the Pacific to the Atlantic and from the United States to the North Pole.

From an area of 540,000 square miles and a population of 3,600,000, Canada has grown to 3,729,665 square miles and about 7,600,000 population.

In 1867 immigration was small and sporadic. In 1913 it reached 402,000 and in 1914, 385,000. Canada, since 1900, has taken the place of the United States as the chief magnet for old-world immigration.

The total value of Canadian field crops in fifteen years rose from $195,000,000 (in 1901) to $841,000,000 (in 1915). The value of live stock has increased threefold in the past fifteen years, reaching $800,000,000 in 1916.

The exportable surplus of Canadian agricultural products in 1868-70 was only $13,000,000; in 1916-17 it was $480,000,000.

The total value of the fisheries catch in 1970 was $6,577,391; in 1915, $31,264,631.

The value of the annual product of the mines has grown from $10,000,000 to $137,000,000 within forty years.

The value of log products in 1871 was $34,156,483; at present it is about $175,000,000.

There were but few factories in Canada at the time of Confederation; to-day the annual value of manufactures is estimated to be over $1,300,000,000. Such products as wood pulp, automobiles, electrical apparatus, etc., which were unknown in 1867, now run into many millions of value annually.

In 1871 the manufactures of iron and steel were considerably less than $3,000,000, while in 1915 they reached $50,000,000 and this figure has been greatly increased by the war. Foundry products, which valued a little more than $7,000,000 in 1871, were worth approximately $37,000,000 in 1915. The manufacture of railway and other cars in 1871 amounted to half a million dollars; in 1915 this item had increased to $25,000,000. Just about $1,000,000 worth of paper was manufactured in 1871, and in 1915 thirty times as much was made.

At the time of Confederation about $20,000,000 had been expended on the improvement of the waterways of Canada; to date the expenditures on canals alone exceeds $106,000,000.

There were no roads or streets of permanent construction in Canada at the time of Confederation, while now every province in Canada has a good roads organization and every city has spent thousands—and some of them millions—upon street improvement. Quebec and Ontario have spent many millions of dollars upon road work, yet the good roads movement in Canada is still in its infancy and hundreds of miles of urban streets are still unpaved.

The science of building construction has probably advanced as far during the past half century as has any branch of engineering. The modern steel skyscraper, so familiar a sight in all large Canadian cities to-day, is a far cry from Toronto's famous first "Iron Block," with its cast iron columns and wrought iron floor beams. Thirty-five Canadian cities issued building permits totalling $38,783,994 in 1916, and $32,285,721 in 1915. Fifty-two Canadian cities issued building permits totalling $166,114,508 in 1913, and $94,807,577 in 1914. Compared with these figures, of course, the annual value of buildings erected about the time of Confederation was insignificant. Steel, cement, asbestos and many other modern materials were practically unknown then. Nearly all construction was of wood, brick or stone; mostly wood.

Bridge building, too, has developed rapidly. The wooden bridges of 1867 have largely been replaced by iron, steel or concrete structures. Nowhere in the world have difficult problems of design and construction of bridges been more successfully solved than in Canada. The Quebec Bridge, the Lethbridge Viaduct, the Victoria Bridge, the C.P.R. St. Lawrence River Bridge, the Outlook Bridge, the bridges at Niagara Falls and those in the Rockies may be mentioned among many Canadian structures known throughout the engineering world.

At Confederation there were 2,278 miles of railway in Canada, with an investment of $257,000,000. To-day there are 35,582 miles, involving a capital of $1,876,000,000. The freight handled in 1867 amounted to

5,070,000 tons; in 1915, there were carried 101,394,000 tons. Slightly over 5,000,000 passengers rode on Canadian railways in the year of Confederation, while for 1915 this figure exceeded 46,000,000.

The above figures do not include electric railways, of which, of course, there were none fifty years ago. In 1915 the mileage of electric railways in Canada was 1,590, and the passengers carried in 1914 numbered 615,000,000.

In 1867 there were just seven waterworks plants in Canada; in 1915 there were 528 such enterprises, including 72 filtration plants, and involving an expenditure of $123,725,033 and annual maintenance charges of $4,558,539, exclusive of interest on the capital charges.

At Confederation there were comparatively very few sewers in Canada. In 1915 there were 279 sewerage systems in the country, costing $77,723,353, including 75 sewage treatment plants.

There were 13,057 post offices in Canada last year as compared with 3,638 in 1868, and the respective revenues of the post office department for those years were $808,000 and $13,046,000.

Canadian telegraph companies now handle 12,000,000 messages annually, compared with an absolutely insignificant business in 1867. Over fifty wireless stations have been built, and there are half a million telephones in use in Canada. The telephone, of course, was wholly unknown fifty years ago. The wire mileage of the telephone companies is approximately 1,500,000.

Imports in 1868 amounted to $68,500,000; in 1917, $845,300,000. Exports in 1868 were $45,500,000 as compared with $1,151,300,000 for 1917. Customs duties amounting to $8,800,000 were collected in 1868, compared with $147,000,000 for the fiscal year ending in 1917. Among the exports for 1917 were $85,600,000 worth of mine products compared with $1,276,000 for this item in 1868. Aluminum exports now amount to over $3,500,000 annually, and paper exports to more than $20,000,000.

The total assets of the Dominion Government at the time of Confederation were $17,000,000; to-day they are about $322,000,000. The total Dominion revenue on consolidated fund, which was $13,600,000 in 1868, was $172,100,000 in 1916.

The total on deposit in chartered banks grew from $33,000,000 in 1868 to $1,418,000,000 in 1916, while the post office savings bank deposits grew from $212,000 to more than $10,000,000. The amount to-day on deposit in all government savings institutions is over $54,000,000.

The only business paper in Canada in 1867 was The Monetary Times, of Toronto, and three other commercial papers which were absorbed by The Monetary Times. To-day there are 147 trade or class journals, representing every line of industry.

There are 26,000 schools in Canada, compared with 10,000 at the time of Confederation. The expenditure on education amounts to about $56,000,000, compared with $2,500,000 in 1867.

Canada has recruited 411,000 soldiers, and has sent 311,000 overseas. She has manufactured and shipped over $525,000,000 worth of munitions to date.

The necessity for restoring the devastation caused by the war must throw unlooked-for opportunities upon the newer countries of the world and especially upon Canada. Only a little more than one-ninth of the soil available for agriculture has been improved to date. There are possibly 390,000,000 acres of agricultural soil still available, of which probably 100,000,000 acres could be immediately improved. There are 500,000,000 to 600,000,000 acres under forest in Canada, half of which area carries timber of merchantable size. The mineral potentialities of the country are enormous, as are also the water power resources. In Canada to-day about 1,850,000 e.h.p. are hydraulically developed, and there are available falls totaling over 15,000,000 horse-power still undeveloped, probably not more than one-third of which are so far distant from settlement as to be impossible of development under present conditions.

With natural resources such as these to draw upon, we may, at this fiftieth anniversary of our nation's birth, look to the future with just confidence.

PERSONALS.

A. W. McVITTIE, of Victoria, B.C., has been gazetted a member of the Corporation of British Columbia Land Surveyors.

W. G. MURRIN, formerly general superintendent of the British Columbia Electric Railway Co., has been appointed assistant general manager.

R. H. PARKS has been appointed operating manager of the Canadian Car and Foundry Company, and W. S. ATWOOD has been appointed assistant to W. W. Butler, vice-president and managing director.

E. COTTON, a land surveyor of Victoria, B.C., has joined the Sixth Field Company, Canadian Engineers, at North Vancouver for overseas service. Mr. Cotton is a native of New Westminster and has had eleven years' experience in survey work.

N. A. MARSH, of the John verMehr Engineering Company's engineering staff, Toronto, has left for an extended trip to Brazil, South America, to supervise the erection of the verMehr water filtration plant which is being constructed at Pernambuco.

FRANK H. CROCKARD, formerly vice-president of the Tennessee Coal, Iron & Railroad Co., a subsidiary of the United States Steel Co., in active charge of construction and operation, with headquarters at Birmingham, Ala., has been elected president and general manager of the Nova Scotia Steel and Coal Company, to succeed Col. THOMAS CANTLEY, who has been elected chairman of the Board of Directors. Col. Cantley has been connected with the company for more than 30 years, having been general manager for 16 years, and president for the last two years.

Lieut.-Col. J. S. DENNIS, president of the Canadian Society of Civil Engineers and assistant to the president of the Canadian Pacific Railway Co., has been loaned to Gen. White, commander of the British-Canadian Recruiting Mission in the United States, to assist in obtaining British and Canadian recruits for the army. Col. Dennis will command the western states, with headquarters at Chicago. He expects to be in Montreal about every ten days, however, and will keep in touch with C.P.R. work and with the affairs of the Canadian Society.

T. E. RYDER, former manager of the St. John Branch of the Canadian Fairbanks-Morse Co., Limited, has just been promoted from the grade of lieutenant to that of captain. Capt. Ryder has also been awarded the Military Cross and has been mentioned in despatches upon more than one occasion. Previous to the war he was an officer in the St. John Battery. When war broke out he immediately enlisted for active service and was attached to the Ammunition Column, Heavy Battery. He still retains the title of manager of the St. John Branch of the Fairbanks-Morse Company, with leave of absence for war duties.

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